

CONTROL OF CONSTRUCTION CONTRACTS

Analysis of systems for the control of progress, quality and cost of construction to the client, based upon six cases in building or civil engineering in the UK.

VOL. 2 Case Studies

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Reports of:

PROJECT A

PROJECT B

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PROJECT A

The project was the culverting of a section of brook on a University site.

The Owner of the project was a provincial University. During the design and supervision of the project's construction, the Metropolitan Council of the city acted as the Client and the Engineer.

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ABBREVIATIONS USED

SPECIAL TO THIS REPORT

Client	Metropolitan Council of the City
ED	Client's Engineering Department
DT	Design Team
MT	Management Team
PE	ED's Principal Engineer
Engineer.	PE
AE	Assistant Engineer
DLO	Direct Labour Organization (Contractor)

STANDARD ABBREVIATIONS

RE	Engineer's representative on site
QS	Quantity Surveyor
C of C	Conditions of Contract
B of Q	Bill of Quantities
VO	Variation Orders

1 Project's Nature

1.1 Purpose of the project

The brook provides a natural drain for rainfall and a storm water overflow for urban areas of the city.

The culverting completed the covering of the brook on the University's property. The length of culverting required was 35 m. approximately. It provided the culverting of the brook which would be required if a planned extension to the university buildings was to be constructed. It also completed the covering of the brook throughout the site. A year before it was built children had been drowned while playing in an upstream section of the brook. The University therefore decided to proceed with this culverting in advance of any other need in order to avoid a similar accident on its land.

1.2 Technical description of the project

A sketch plan of the culvert is shown in appendix 1.

Existing masonry walls on either side of the culvert were either strengthened or replaced by reinforced concrete walls, depending on their condition.

The retaining walls of the culvert were divided into four sections A, B, C, and D shown in appendix 1. Each section was erected or strengthened in the sequence of the letters.

After the completion of the top slab of the culvert it was covered with soil and landscaped.

The works carried out on each section were the following:

Wall A. - Grouting of the existing masonry wall.

- Lowering the existing wall after grouting.

Wall B. - Excavation of top soil.

- Sheet piles driven behind the wall to retain the soil when the wall was demolished.

- Demolition of old wall. Temporary struts resting against "wall A". supported the sheet piles as in drawing A of appendix 2 while the wall was being demolished.

- Clearance of foundations.

- Blinding of foundations.

- Building of reinforced concrete wall.

Wall C. - Demolition of old wall and excavation of foundations.

- Pouring of base slab.

- Erection of reinforced concrete wall.

- Pouring of reinforced concrete wall C (shown in sketch B of appendix 2).

Wall D. - Grouting of existing wall

- Built cover wall of reinforced concrete.

Culvert
Bed

- Stone paved bed of the culvert lined, after the water was diverted through a flexible pipe.

Slab - Covering slab of reinforced concrete poured in situ.

Filling and reinstatement

Manholes to the culvert and sewerage pipes were also built in brick, before the site was filled.

1.3 Programme

The constructual period for the execution of the above works was 20 weeks.

The official date of commencement was the end of December, i.e. after the Christmas holidays.

Works commenced in the second week of the following January.

On the 30th of April of the same year, week 19 of the contractual programme, the Contractor received from the Engineer a certificate of substantial completion, plus a two week extension of the contract programme due to inclement weather (1 week) and due to additional works carried out downstream at the Engineer's request.

When the certificate was issued the Contractor had completed the walls and was preparing to pour the concrete of the slab i.e. all the parts where technical risks existed had been completed.

The Contractor stated in writing that he undertook to finish all the outstanding works i.e. the slab the manholes and the filling and landscaping of the site, as these were described in the contract.

The landscaping was completed at the beginning of August.

1.4 Costs

The Contractor's offer, based on the B of Q prepared by the Design Team (DT) was £61,466.

The tenderers at the Engineer's request had included in their offer a technical contingency of £5,260, £3,000 as a general contingency and £2,260 for dayworks. The management of the contingency during the construction was at the discretion of the Engineer.

The final cost of the contract was £60,800.

Out of the £3,000 technical contingency, £1,600 was used for grouting of wall D and the remainder as dayworks.

2 Owner/Client

The Owner of the project was the University. The University had an inhouse architectural team involved with the planning and construction of new buildings and the maintenance and renovation of existing ones. The Architect who was the leader of the team was responsible to the University's Vice-Chancellor.

Because the culvert was a Civil Engineering project, the Architect felt that it was appropriate for the project to be designed and built by the Metropolitan Council of the city (Client) to utilize their Engineering Department (ED).

The ED was responsible for the design and supervision of all the County's Water Authority's sewerage projects carried out in the area of the Metropolitan District Council.

The ED's policy was to carry out the design and supervise the construction of its projects using its own technical staff, unless a specialist was required or the Department was overloaded with work. A Chartered Engineer was usually put in charge of the design stage and was named the Engineer's Representative (RE) during the construction phase.

The ED's philosophy was that a project should be designed to fulfil the expected requirements at minimum cost, and that during the construction phase, keeping within budget was the primary objective.

The Client's policy was therefore to avoid involving the liquidated damage clause included in the C of C unless:

- the works were urgent, e.g. a flood protection scheme, and damages were caused because of late completion.
- the works were related to the provision of infrastructure, e.g. drainage of an industrial estate, for a developer.
- the Contractor had proved incompetent.

The finance of the project was provided by the University.

The Owner's expectation of the project was that the total cost would not exceed the £62,000 estimated by the ED.

3 Management Organization

3.1 Management structure and delegation of authority

The TMC was named in the contract as the Employer.

The Principal Engineer (PE), who was the Director of the ED's Hydraulic Division, was named as the Engineer.

The Group and Senior Engineers shown in appendix 3 were next in the hierarchy of the ED's Hydraulic Division.

The QS shown in the same appendix was answerable to the Principal QS who was the head of the ED's Quantity Surveying Division.

The Engineer was not involved with the running of the project but he received and forwarded all the correspondence to and from the Contractor and signed the interim, final and completion certificates after they were evaluated and approved by the Group and Senior Engineers and were checked by the QS as it is shown in appendix 3.

For this project the Engineer appointed a Chartered Engineer, who was a member of his staff, as his representative (RE) and a junior engineer as the RE's assistant (AE) in order to supervise the construction of the project. (More details about the duties of the various members of the Management Team (MT) appear in sub-section 4.2.)

The RE and AE were based in the ED approximately 1 mile from the site and were also involved under the same capacity with other projects.

The Engineer decided that because the project was straight forward (i.e. no technical difficulties were foreseen) and its size was small it did not justify the appointment of a full-time RE.

A mobile cabin was provided by the Contractor in order to be used by the RE and AE when they visited the site.

The Contractor who carried out the works was the Client's own Direct Labour Organization (DLO) who operated as a Contractor under the provisions of the Local Government and Local Act of 1980 (Direct Labour Organization).

A sub-contractor was nominated by the Engineer, prior to the Contractor's appointment in order to carry out the grouting of wall A. The same sub-contractor carried out the grouting of wall C which was ordered by the Engineer under a VO during the construction phase.

The Contractor intended to carry out the work using one foreman, four labourers and one operator for the sheet piling hammer. His policy was to avoid overtime. He also appointed a part-time Agent who visited the site daily. During these visits the Agent discussed with the RE the progress of the works, as well as problems and the required action.

The C of C were the ICE 5th Edition of June 1973 (Revised in January 1979). The contract was a fixed price contract, because it was the Client's policy that no price adjustment clause should be included in contracts with a less than a year life span.

The specifications were in accordance to "Civil Engineering Specifications

for the Water Industry" published by the National Water Council in 1978, with some special clauses annexed to them.

The B of Q was in accordance with CESSM published by the ICE, and allowed tenderers to quote, if they wanted method-related charges. The successful tenderer had involved method related charges for the cabin and plant.

Five contractors and DLO selected by the Client were invited to tender.

The highest offer was £105,000. The DLO's offer was the lowest, approximately 20% lower than the immediately higher offer, and £1,000 less than the Designer Team's (DT) estimate.

4 Contract Control

4.1 Time control

Soon after his appointment the Contractor submitted a bar chart programme to the Engineer.

The bar chart consisted of eight activities (e.g. build wall B).

The activities were to be carried out consecutively due to the Contractor's limited resources.

During the construction phase the bar chart was not revised by the Contractor to account for:

- the late start of the works on site
- the change of nature of some works, i.e. the grouting of wall D ordered by VO, which allowed the overlapping of some activities.

4.2 Quality and cost control

4.2.1 Daily visits on the site

The RE or the AE visited the site daily.

The AE carried out the measurements of the works and kept a diary on the daily progress. He also reported to the RE on problems.

The RE visited the site once or twice every week. During his visits:

- he examined the quality of the finished works and decided on remedial works which the Engineer requested in writing.
- he ensured that works were carried out according to the design specifications e.g. before pouring concrete he inspected the site

in order to ensure that the reinforcement bars had been placed properly, the foundation was cleared,

- in cooperation with the Agent, they examined possible alternative technical solutions to those stated in the design and as the work progressed and problems arose. Depending on the scale of the alteration solutions were agreed and a new work programme was worked out on the spot. The time and cost implications of the alterations were estimated.

If major alterations were required, e.g. a part of the project had to be redesigned, the RE tried, where it was possible, to sketch the new details, thus avoiding delays to the Contractor while the final detail drawings were prepared.

4.2.2 Issuing of VO's and settlement of claims

Instructions with minor cost implications were issued by the RE verbally.

In the case of major alterations the RE discussed, on the same day he had examined the possible options with the Agent on the site, the alternative solutions with the Senior or Group Engineer, before the Engineer issued a VO.

All the claims were negotiated by the RE and the Agent.

Before they were approved by the Engineer the QS had to initial them.

Thus VO's were issued and claims were settled under the following standard procedures:

- The RE decided that a VO was required. The nature of the VO and its

implications (cost and/or time) he discussed with the Senior and/or Group Engineers.

- The approved (by the Senior and/or Group Engineer) VO was forwarded to the Engineer, who provided that he agreed issued it to the Contractor.
- The Contractor sent his evaluation to the Engineer.
- The evaluation was checked by the RE and QS.
- If agreed the Engineer approved the claim.
- In case of disagreement the QS and RE met the Agent and the Contractor's QS and tried to reach an agreement.
- If agreement was not reached the Engineer fixed a price.
- Arbitration, was called for when the Contractor disagreed with the Engineer's decision.

4.2.3 Monthly meetings

During the third week of each month the Client and the Contractor met to discuss the Contractor's ongoing contracts of the Hydraulic division.

The participants in those meetings were:

For the Client

Group Engineer
Senior Engineer
Resident Engineers

For the Contractor

Principal Engineer
Senior Engineer
Agent

All the participants received the minutes of the meeting.

The overall performance of the Contractor for each individual contract was discussed during those meetings and decisions were taken. For example in the meeting of February, the delay to the works programme was discussed and the Contractor was urged to increase his labour force in order to meet the target date. The Contractor was also asked to

provide an updated version of his bar chart.

In response to this meeting the contractor increased his labour force temporarily from four to eight.

Besides the overall performance of the Contractor issues concerning health, safety etc. were also discussed.

5 Causes of Cost Increases and Delays

5.1 Cost increases

1. When the top soil was removed, it was realized that the existing wall D would have to be grouted because it was not as thick as had been assumed in the design.

The nominated sub-contractor who carried out the grouting of wall A was assigned by the Engineer to grout wall D.

The additional cost was £1,600 and was met by the general contingency. The need to grout wall D did not interfere with the contractor's programme.

2. Some other minor alterations to the design were introduced when the original walls were excavated. One such example was the change to the design of wall B shown in appendix 2. When the wall was excavated the RE realized that it would have been more practical to build the new wall as shown by the thick line. The cost of the excavation of area (b) carried out was balanced by the cost saving due to the originally planned excavation of area (a) which was not carried out. Thus the Contractor only received additional payment for the extra length of the mesh (c) shown in the appendix.

5.2 Delays

The construction works, compared to the Contractor's programme submitted to the Engineer after the award of the contract, were delayed by six weeks, i.e. the floor slab was completed at the end of June instead of the second week of May.

The delays occurred because of the following reasons:

A Weather

1. One week was lost in January due to exceptionally bad weather, temperatures below zero, snow etc., delayed the grouting of wall A. The Contractor's programme was therefore extended by one week.
2. When the works were stopped because of the increased flow of water in the culvert, following a flash storm, one week was lost during the erection of wall C.

In the RE's opinion the Contractor was not entitled to a time extension for such a delay because the Contractor was expected to have made allowances for it in his tender offer. i.e. his rates should have been adjusted to allow for the acceleration of costs, e.g. additional manpower, to make up for time lost for such reasons.

B Additional work ordered by the Engineer

The works stopped for one week in April because the Engineer instructed the Contractor to divert his labour force in order to carry out some repair works downstream.

The Owner's Architect agreed to the delay caused by these essential repair works, because he realized that it would have been difficult to carry them out once the culvert had been covered.

The cost of the repair work was covered by the Client's budget and the contractual time was extended by one week.

C Management of the Contractor's resources

1. In addition to bad weather the commencement of the works was also delayed because the hammer for the sheet piles was in use in

another site and it was not made available until the 15th of January.

2. Approximately two weeks were lost during construction, because of the Contractor's limited manpower resources.

The Contractor's rate of progress was vulnerable to absenteeism, sickness etc., because for the best part of the construction phase he carried out the works with one gang which consisted of four labourers. Thus when delays occurred, because of his limited resources and his no overtime policy, the Contractor could not accelerate the works in order to make up for the time lost.

6 Effectiveness of the Control System

6.1

The total cost of the design and supervision was £8,700 i.e. 12% of the total cost of construction.

The supervision was estimated to be £4,700 and was made up mainly of the Client's overheads.

6.2

The RE felt that:

- a. The cost of the tight supervision adopted during the construction of the project, i.e. daily visits by himself or his assistants on the site, was justified because it was the only way to ensure that the quality of the works would comply with the specifications and design.
- b. The Client's Management Organization was suitable for the type and size of projects the Client implemented, because decisions, when problems arose, could be taken quickly, either by the RE's or as a result of consultation the same day the problem arose, with their supervisors.

6.3

The RE was of the opinion that in the case of small projects like the culvert, an experienced supervisor:

- could plan the works on a weekly basis
- could forecast the total cost, with reasonable accuracy, and thus keep within budget by controlling the VO's he had to issue.

6.4

For larger and more complex projects, the Client in order to meet the Water Authority's requirement for accurate payment forecasts, had included a clause in the C of C requesting the Contractor to produce a network programme and revise it every three weeks.

A member of the Client's staff was also assigned on site as a full-time Clerk of works in order to:

- carry out quality controls
- keep a diary of the progress of the works
- do occasional measurements

7 Comments by RE and the Architect

Both the RE and the Architect expressed the opinion that the Owner got good value for the money he invested in the project, because:

- of the good quality of the finished works
- the final cost of the project was lower than the cost estimate of the design and the Contractor's tender.

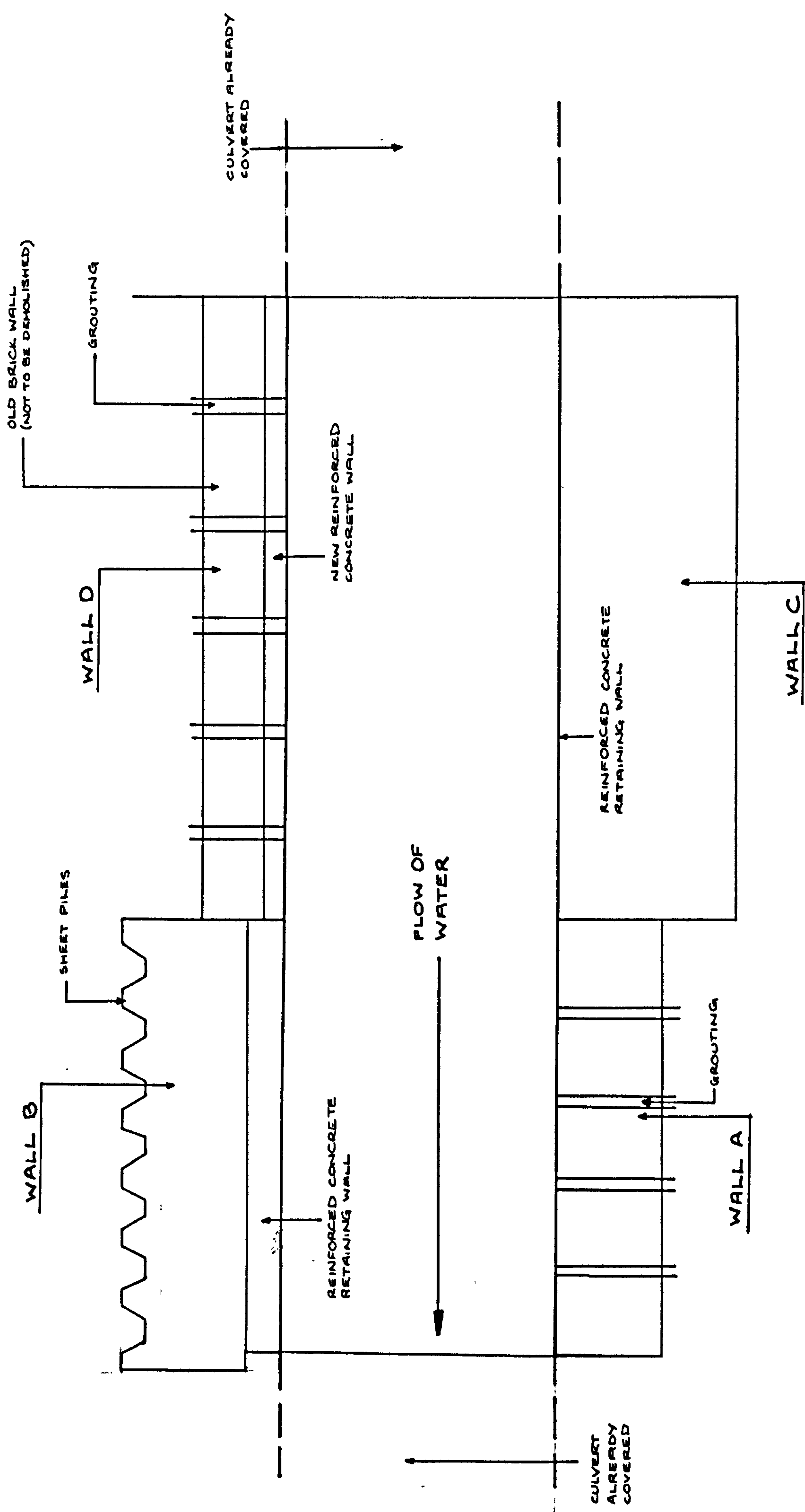
Starting the project was urgent, to limit the time that the brook was open to passers-by. Once the Contractor has begun work his fence and his presence during working hours gave some added security, but until the manhole cover was on and secured there remained some risk of people entering unbeknown to us and getting into trouble.

Finishing the project i.e. landscaping etc. within the contractual time was not important for the Owner or the Client unless the time over-run would increase the final cost above the budget.

Neither the Architect nor the RE therefore thought that it would be justified to impose the liquidated damage clause because of the four week over-run.

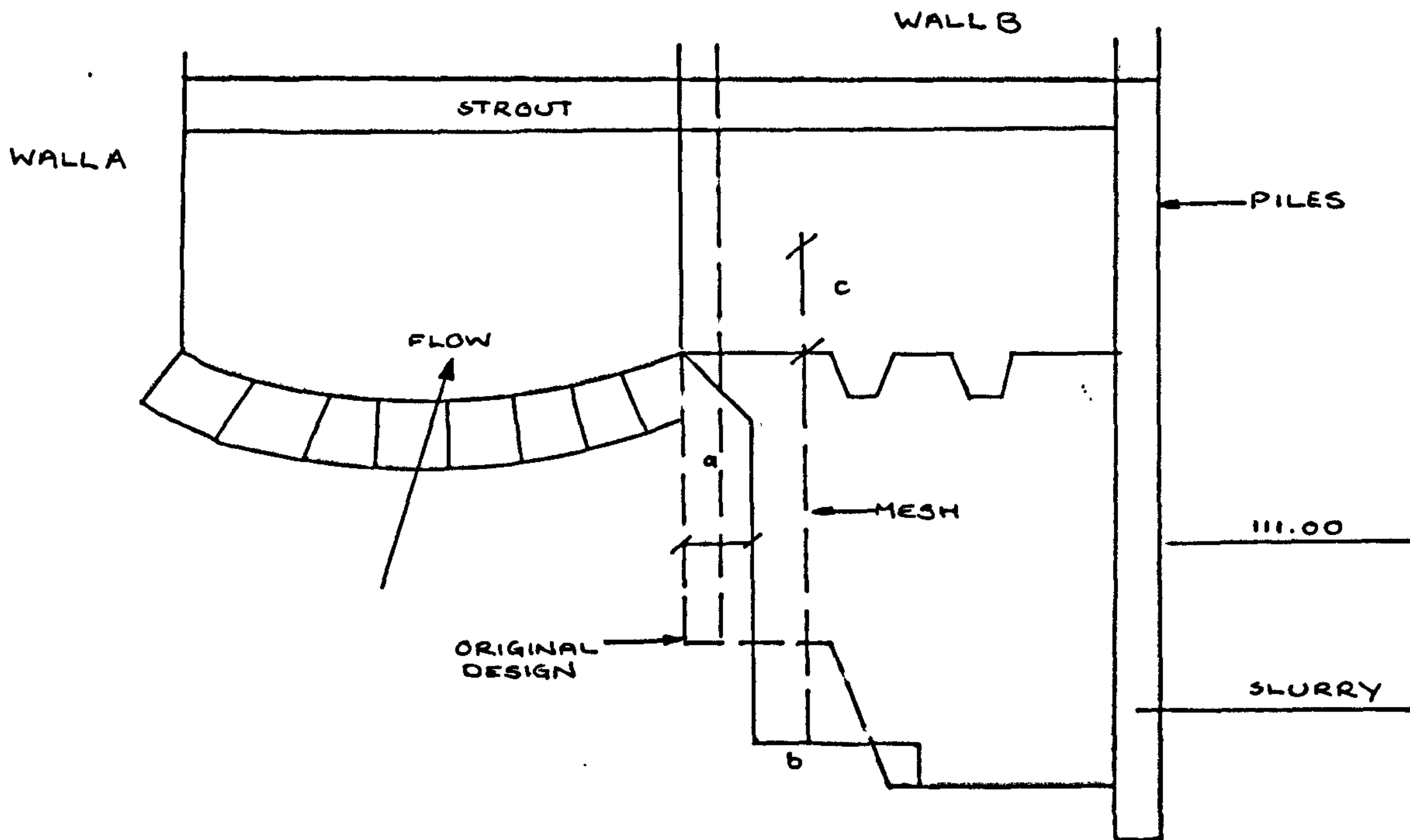
PLAN OF WESTBROOK CULVERTING

APPENDIX I

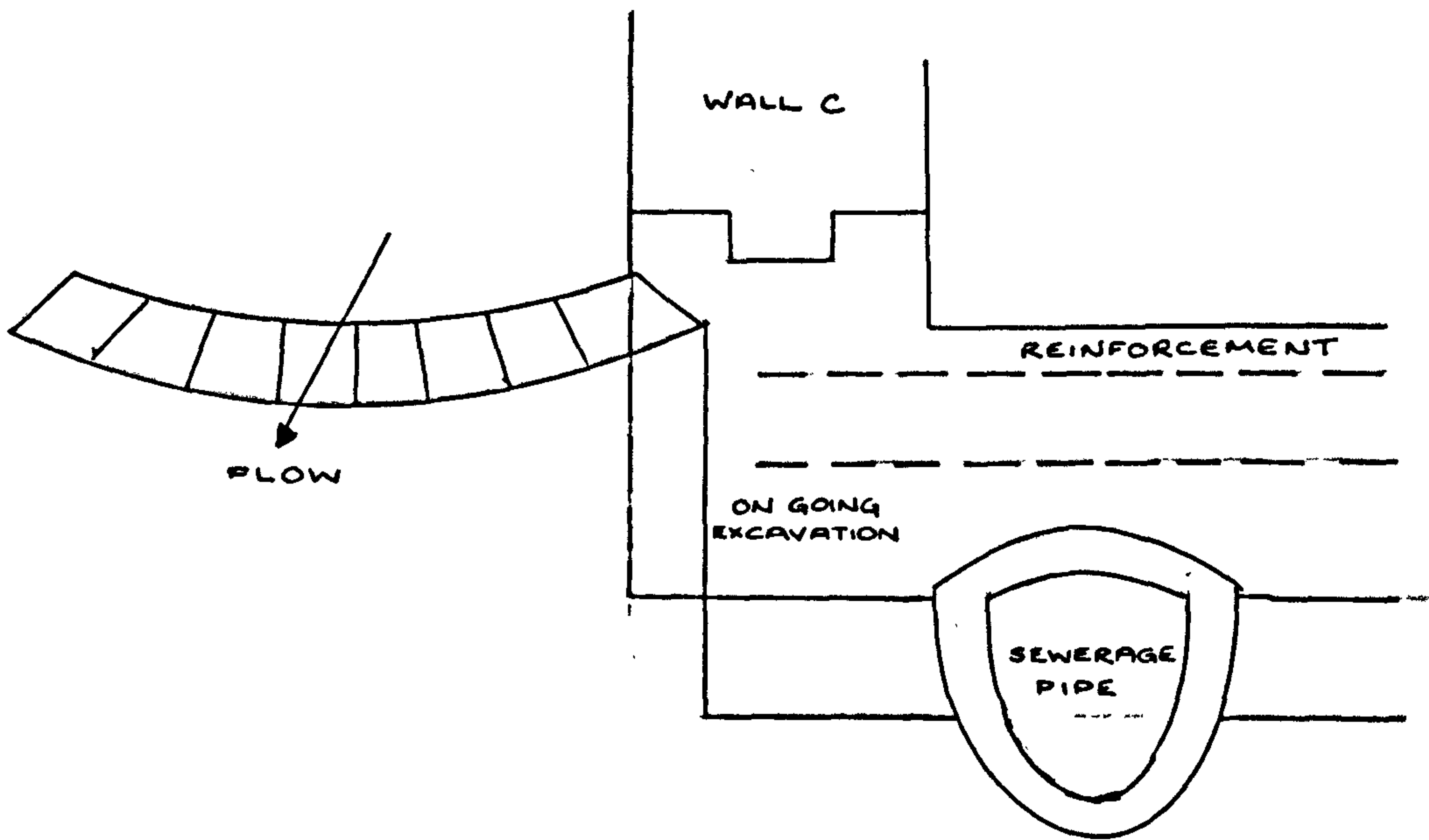


CROSS SECTIONS OF CULVERT

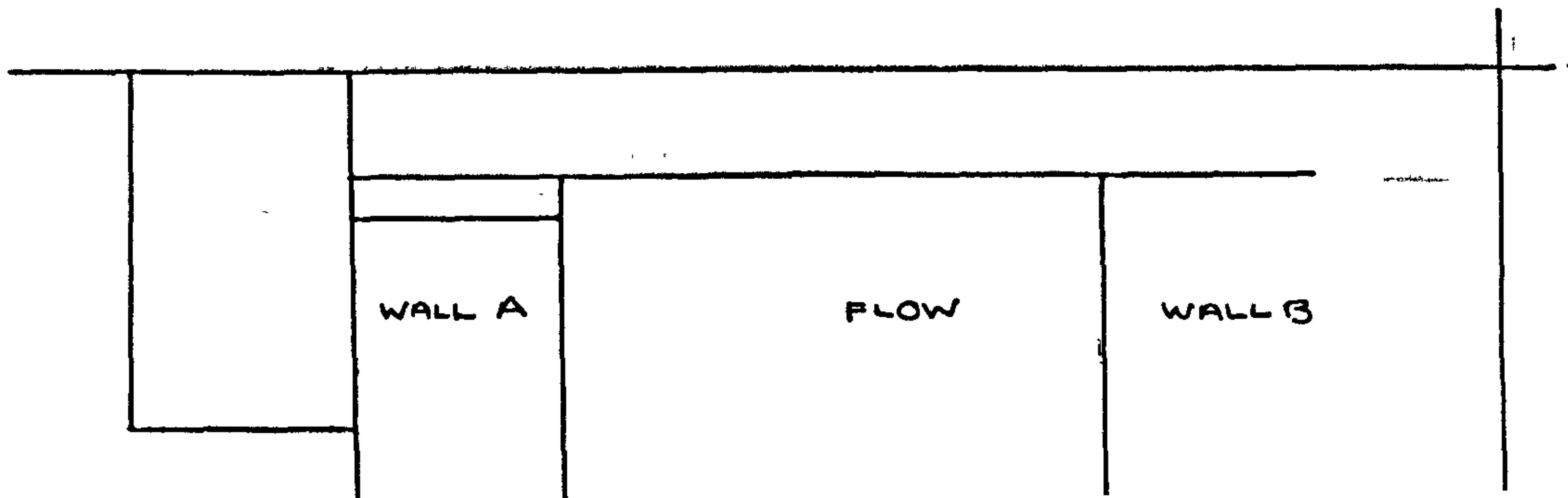
DRAWING A



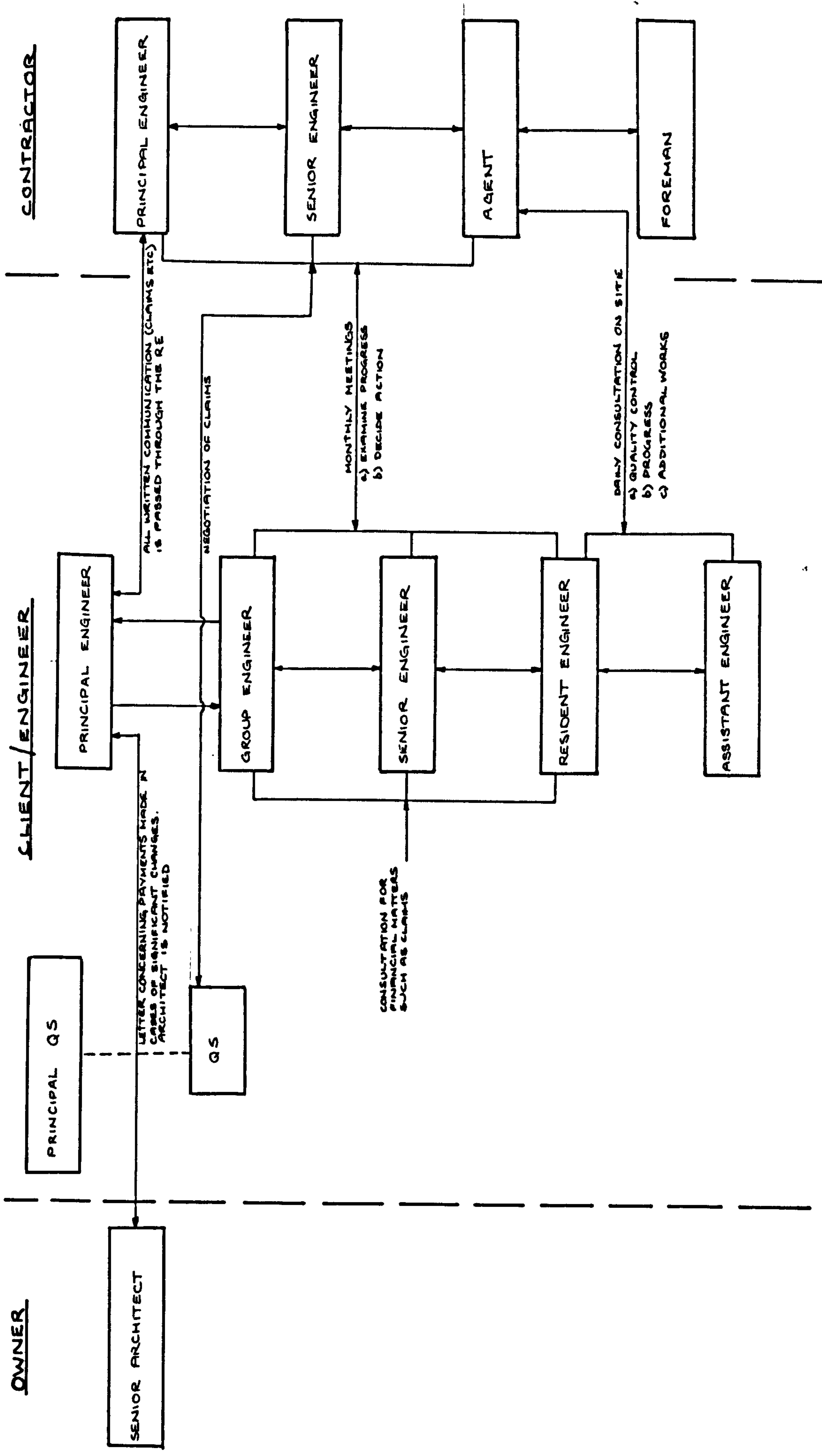
DRAWING B



DRAWING C



LINES OF COMMUNICATION WITHIN THE MANAGEMENT STRUCTURE



PROJECT B

The project is a rapid transit system which connects the centre of a town with several conurbations around it.

The Passenger Transport Executive (PTE) of the county in which the town is located was responsible for the design, construction, commissioning and operation of the project.

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7. Conclusions (to follow final meetings)

ABBREVIATIONS USED

SPECIAL TO THIS PROJECT

PTE Passenger Transport Executive (Client)

MT Management Team

Members of MT

EXECUTIVE Director General & three Directors of the Client

MG Management Group

PD Project Department

PCT Project Coordination Team

PCO Project Construction Organization

Members of PD

PC Project Coordinator

CCE Chief Civil Engineer

ESM Equipment & Systems Manager

FC Financial Controller

Officers of PD

CAO Cost Analysis Officer (PCT)

SPE Senior Progress Engineer (PCT)

PE Project Engineer for appropriate section of works area (PCT)

SAA Senior Administrative Assistant (Client)

SA Senior Accountant (Client)

Reports

PSR Project Status Report

PCS Project Cost Statement

Documents

APC Administration of Project Contracts procedure

PCIAP Project Contract Internal Administrative Procedures

STANDARD ABBREVIATIONS

M & E	Mechanical & Electrical
RE	Resident Engineer
ICE	Institution of Civil Engineers
C of C	Conditions of Contract
B of Q	Bill of Quantities
VO	Variation Orders
PC	Prime Costs
PS	Provisional Sums

PROGRAMME YEARS

Year 0	Parliamentary Act authorizing construction
Year 1	Award of first Contract
Year 2	Base prices refer to November of year 2
Year 7	Opening of phase I at the end of summer
Year 10	Completion of phase V

1. Project's Nature

1.1 Justification of project

Some of the traditional industries in heavy engineering etc which sustained the population of certain conurbations surrounding the town had been declining.

The number of jobs in areas outside these conurbations and especially in the town centre, had been increasing.

These changes in employment patterns resulted in people having to travel further to find jobs. Relatively few people owned cars, so there was a need for a much better system of public transport.

There was already a good inter-urban road system and a comprehensive local bus system.

The existing suburban railway played little part in meeting the increase of demand, because it did not serve some of the important conurbations.

The purpose of the project was therefore to provide a rapid transit system integrated with the buses in order to:

- create and encourage new sources of employment
- enable the population to travel further to new jobs

1.2 Technical description

The project comprised 56 route kilometres, 43 of which were converted from the existing suburban railway system. The remaining 13 km was new construction, 5 km of which was in tunnel.

Major structures

A continuous steel three span bridge 352.5 m long.

Two (2) new viaducts of 104.7 m total length.

Infrastructure

Seven (7) underground stations

Seven (7) interchanges with buses.

Twenty-seven (27) surface stations

Twenty-two (22) crossovers

Three (3) terminals.

One (1) depot for car servicing and maintenance

One (1) control centre

Rolling stock

A fleet of ninety (90) cars

1.3 Programme

The construction of the project was carried out in five phases. Year one was the year the first contract was awarded. Our observations began in the middle of year 8. During our observations the phase IV was opened for traffic and V was underway.

The following table gives an indication of the opening dates of the five phases:

1. Phase I 19 kms long, end of summer of year 7
2. Phase II 4 kms long, in spring of year 8
3. Phase III 5 kms long, in autumn of year 8
4. Phase IV 14 kms long, in autumn of year 9
5. Phase V 13 kms long, end of year 10

The original estimate made in year 0 was that the construction of the project would be completed in seven years ie by the end of year 7.

For the five phases of work, 100 civil, electrical, mechanical etc, contracts were awarded.

The value of those contracts varied from £0.2 million to £7.0 million and their life span from a few months to three years.

Appendix 1 shows the number of contracts awarded each year. The peak was reached during years 4 and 5. During these years approximately 35 major contracts were simultaneously in progress.

1.4 Cost estimates

The original cost estimate, was £65.5 million at January year 1 prices. This figure did not include design fees, site supervision, land costs and contingencies for non civil engineering works. The estimate was revised to £170.1 million at November year 2 prices (base prices for all the contracts). The above items and the increases due to inflation for the three years were included in the new estimate.

In May in year 3, the Government placed an embargo on the award of new contracts, so that the project costs could be re-examined. As a result the total cost estimate was reduced by £10 million, to £160.9 million. This reduction was achieved by lowering the quality levels for example, some architectural finishes were either omitted or substituted by cheaper ones, the station platforms were reduced from 3 to 2 car lengths etc.

The embargo was lifted in December of the same year.

In year 9 the total cost estimate in base prices was estimated at £171.7 million or £280 million in out-turn prices ie at prices ruling as work was completed.

The approximate increase of £10 million was due to:

- expenditures which occurred prior to the embargo and which were not inflated to base prices
- delay caused by the embargo. (The cost of both of them was estimated at £2.5 million).
- delays due to negotiation of ownership and operation and the costs of compensation
- the reintroduction of some of the omitted works which the Client considered essential.

The graph and table contained in appendix 2 show the cumulative and annual expenditures, in base prices as they occurred up to year 8, and their respective forecasts to the end of the project's construction phase.

As it can be seen in the appendix, out of the £171.7 million, £108.4 million was spent on civil engineering works, £45.5 million on M & E works and supplies, and £17.8 million for other expenses.

The other expenses are the costs paid to BR for the replacement of depots, construction of alternative routes etc, which were taken over by the project.

These works were carried out by BR's own workforce, and the Client re-

imbursed their costs as the works progressed. In year 3 their costs were estimated at £10.1 million in base prices, as opposed to the year 10 estimate of £17.8 million.

2. Owner/Client

2.1 Client's characteristics

2.1.1 Client's nature and legal status

In year 0 an Act of Parliament both authorised construction and as a decision had not been reached at the time, provided for an agreement between the PTE and BR on ownership and operation of the Metro.

In year 1 the County Council became responsible for transportation and structure planning within the conurbation and assumed the role of Passenger Transport Authority (PTA). Thus the County's Passenger Transport Executive (PTE) became the Owner of the project. The members of the PTE were appointed by the County Council. The PTE was a separate statutory body, but the County Council were their political masters.

The responsibilities of the PTE were the following:

- a. running the buses
- b. running the project
- c. integration of public transport services. This integration involved dealing not only with the services they operate themselves, but also with those of the National Bus company subsidiaries operating within the area of BR's local services financially supported via a specific agreement
- d. public transport planning

The Owner was also acting as the Client (Promoter) for the project since he was responsible for the project's planning, design, construction and commissioning.

2.1.2 Client's experience with similar project

The Client had never promoted or administered the construction of such a large and complex project before.

2.1.3 Sources of the project's finance

The project's main source of finance was a direct grant from the Central Government. This grant was awarded in year 0 and covered 75% of the then cost estimate.

Following the Central Government's embargo, the grant was revised to 70% of the £160.9 million cost estimate in base prices.

The embargo was lifted once the Council agreed to the following conditions:

- a. that the Council would not commit itself to any new major transport works until the project was finished
- b. that the revenue support for all the County public transport eligible for grant would be limited to £5 million
- c. that a quarterly report on the project's expenditure would be submitted to the Department of Transport
- d. that two assessors, one from the Department of Transport and one from the Council, would be present in the biweekly Management Group meetings (described under the Management structure heading).

The remaining £10.8 million (at base prices) was contributed by the County Council, from money released through the leasing of rolling stock instead of buying it, and also from EEC regional funds.

2.2 Client's expectations and objectives

2.2.1 Expectations

The Client's expectations was to provide a project which would fulfil the purpose, described in sub section 1.1, at a reasonable cost. (ie good value for money).

The Government, because of an international financial crisis, intervened in year 3 and pressed the Client to complete the project at a minimum cost.

The target budget of £160 million, in base prices, and the terms imposed on the Council before the embargo was lifted were the compromise solutions to the above conflicting expectations.

The Client's wish to achieve higher quality standards resulted in the raising of the target budget by £10 million, provided by the Client and the EEC, to £170 million in base prices.

2.2.2 Objective

The Client's primary objective during the design and construction of the project was to balance the cost, time, performance inter-dependent variables, so that the total cost in base prices would not exceed the sum of £170.7 million.

Thus during the pre-tender, tender and construction periods, the following conditions were observed:

a. In the pre-tender period

- i) The overall time schedule, and the time schedules of the critical contracts, were prepared with the aim to keep the

total cost of the project within the £170 million and not complete the project in the minimum time

- ii) The performance (quality) standards were lowered if there was a danger of exceeding the total cost. (In some cases the specification of some aspects such as architectural finishes etc were left to be decided during the construction phase).

b. At the tender period

- i) In most of the cases the contractors had to tender for contracts, the time schedule of which was fixed ie tenderers were not invited to suggest an optimum between cost and time.

c. In the construction phase

- i) New expenditure in the form of new contracts etc had to be checked before approval against the total cost limit (£170 million)
- ii) When problems arose, such as strikes, bad weather etc, in critical contracts, cost was the decisive factor in the decision making. For example, if a contractor was delayed by unexpected causes, then the works would only be accelerated if the anticipated cost of the delay because of interference with other contracts etc, was going to be higher than the extra cost of the acceleration of the works
- iii) If there was a danger of exceeding the sum of £170 million the excessive sum would be totally or partially (depending on the size of the additional expenditure) balanced by lowering the quality standards.

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If the total cost was lower than the £170 million, the difference would be used towards the project, eg for the provision of extra facilities etc.

2.2.3 Client's attitude

The Client decided to become actively involved with the management of the project.

Because of the project's size and complexity it was decided by the Client to set up, in his headquarters, a Project Coordination Team (PCT) to assist him with the project management. The nucleus of the PCT was provided by a firm of consulting engineers with experience in the administration of design and construction of similar projects.

The PCT in itself was part of a "Project Team" comprising the Client's employees and those seconded by the Client.

The organisation of the Project Team, ie its structure and the delegation of authority to take decisions, to its members, is described in the following paragraph.

3. Management Organisation

In year 0 once the Government approved the grant, a project coordination contract was awarded, after competition, to a firm of consulting engineers. The consultant's main responsibility was to coordinate the activities of all bodies appointed by the Client for the purpose of constructing and commissioning of the project within the budget cost and the time schedule.

One of the consultant's senior engineers was appointed as Project Coordinator (PC). The Project Coordination Team (PCT) was formed as a seconded organisation, as part of the Executive management function under the Client's Director of Engineering who was the nominal Project Manager. The PCT was made up from members of the consultant's and the Client's staff. Its duties were completely separated from any other duties the consultant undertook in relation to the project.

The functions of the PCT were clearly defined in an agreement between the Client and the consultant. The functions covered a range of duties, from the development of administrative procedures for the project, to exercising close control of programmes and costs throughout the project's construction and commissioning.

3.1 Management structure

As a result of the PC's recommendations a management team (MT) was formed in year 2. The three levels of the MT were: (levels appear in appendix 3)

- a. The Executive, which consisted of the Director General and three of the Client's Directors (one of which was the Director of Engineering)

- b. The Management Group (MG) which was made up of three members of the Client's senior staff, the PC and two assessors; one from the Department of the Environment (D of E) and one from the County Council
- c. The Project Department (PD), which consisted of the PCT, members of staff of the Client's engineering, accountancy and property sections, and the "Engineers".

Five Consulting Engineering firms, four civil and one M & E, were employed by the Client in order to design sections of the project. During the execution of the works they designed, each of these firms acted as "the engineer" and Representatives of the Engineer were appointed (RE) (as the terms were defined in the relevant conditions of contract (C of C) with contractors).

Three of the Civil consultants provided architects who detailed the architectural content of the concept. The concept was set by the consultant architect employed by the Client.

The Client's Director of Engineering also acted as "the Engineer" for a number of signalling, communication, overhead and minor civil contracts which were designed by his department.

3.2 Delegation of authority to members of the DT

On the PC's recommendations, the standing orders of the Executive were expanded and powers were delegated to the MG. Thus the MG, which was created in year 2, became responsible for the control of the project during the construction and commissioning periods of each phase. It met twice a month, but additional meetings could be called

by the PC. At its meetings the MG debated and approved or rejected requests by consultants, processed by the PCT, and presented by the PC, for all actions which would result in additional expenditure, eg issuing of variation orders (VO), tendering and awarding new contracts etc. During the same meetings the progress of the works was also discussed, and based on the PC's recommendations new data targets were set. The members of the Executive received the minutes of the MG's meetings.

Once the MG had decided to recommend an additional expenditure, authority had to be obtained by one or more of the Executive members. The number of the Executive members who had to sign the authority form depended on the size of the expenditure.

During the construction period the PCT's objective was to provide the MG with the right information, without delay. In order to achieve this requirement the PCT had to process data received by the Engineers and their own progress engineers and thus:

- to programme and estimate costs, of future contracts to be approved by the MG and Executive
- to monitor the time schedules and costs of the ongoing contracts against the targets set by the MG and authorised by the Executive.

The PCT was divided into four departments, Civil, Electrical, Mechanical and Cost Control. All these departments operated under the leadership of the PC who was responsible to the Project Manager.

When the initial stages of the project were opened to traffic in year 7, and the Client's engineers had to undertake the maintenance

and operation of finished lines, the role of the PCT was expanded. This expansion was necessary in order to provide, in addition to their above functions, assistance to the Client in ensuring that its technical requirements were met. Thus the Project Construction Organisation (PCO), shown in appendix 4, was formed by the Executive with the purpose of constructing and commissioning the remaining phases.

The PCO incorporated staff under the PC for fulfilling the responsibilities of the Client for all the construction and equipping works where the Engineers were employed and for those parts designed and supervised by the Client's engineering departments.

For the contracts where the Director of Engineering was named as the Engineer, he was not functioning as a member of the Executive when these contracts were administered.

The Consultants acting as the Engineer for contracts were the link of communication between the Contractors and the rest of the MT members. Their duty was to ensure that the works were carried out to the quality standards set out in the design within the time and cost targets approved by the Executive. They were expected to be independent in their interpretation of the C of C's. The management of the contingency money and their power to grant time extensions according to their judgement had been removed from their discretion, because the authority of the Executive was required before the Client was committed.

For the directly controlled contracts a separate section was set up

within the Client's Organisation with the clearly defined roles of "Engineer" and "Engineer's Representative" (RE) on the site. For this type of contract the contractor was formally notified of the powers delegated by the Executive to the Engineer and his representative.

Separate arrangements were made between the Client and BR in order to coordinate the BR's works. At an early stage of the project, BR appointed a Project Manager who was responsible for the execution of those works. The Project Manager was based at BR's regional headquarters, approximately 100 miles away from the location of the project.

The Project Manager of BR and the PCT of the two organisations met monthly, in order to monitor the progress and the expenditure of BR works. They reported to a Joint Committee chaired jointly by the Client's Director of Engineering and BR's Chief Planning Officer. The Committee was formed as a decision making body, and its members met twice every month.

3.3 Types of contracts

All the contracts placed by the PTE for civil engineering and building work were of the admeasurement type with price variations. The contracts for the civil engineering works were in accordance with the ICE C of C 5th Edition. The contractors were selected in two stages:

- a. In the pre-selection stage, a number of interested contractors, maximum six, were selected, based on their experience in relation to the tendered works, their reliability as contractors etc
- b. In the second stage the preselected contractors were asked to

submit price tenders, based on the drawings, specifications and B of Q prepared by the Engineer.

Usually the lowest tenderer was selected, unless the PC in consultation with the Engineer felt that the offer was unrealistic. The time schedules of the contracts were fixed by the PC, based on the "programming" explained in the following paragraph. For some critical contracts the contractors were asked to submit their own time schedule and relative tender price.

In some cases the contractors were free to decide if they wished to include Method-Related charges in their offer. Following a recommendation of the PC to the Engineers for each civil engineering B of Q the Engineer had to obtain offers from at least three suppliers. Before tendering, design drawing, specifications and a B of Q were produced by the Engineer.

Detailed drawings were produced and issued during construction by the Engineer.

The Mechanical and Electrical (M & E) contracts were in accordance with the IMechE/IEE/ACE model form A contract.

JCT contracts were also awarded for small architectural works such as kiosks etc. For small works directly controlled by the Client's engineering departments, minor forms for contracts were produced.

4. Contract Control System

The purpose of the system was:

- a. To provide the PC with updated cost and progress information from the Engineers and processed by the PCT so that the PC could advise the MG on:
 - action for the solution of problems concerning ongoing contracts
 - commitments in relation to future works
 - the implications on time-cost-performance of variations requested by the Client
- b. To communicate decisions taken by the MG or Executive to the Engineers.

The PCT recognised that the timing of the information supply - decision making - conveying of decisions, cycle, was important if the decisions were not to be made in retrospect ie to endorse actions already taken on the site level.

The policy for control, as it was defined by the PC was:

- a. good programming and careful monitoring of progress so that adjustments can be made soon enough to minimise expensive delays
(control of time)
- b. good estimating and practical method of organising and recording these estimates (budgeting)
- c. tight control of expenditure of additional money required during construction by practical methods of authorising and recording such variations (Control of cash).

Thus the system was divided into two branches:

- Programming and progressing set up to satisfy a

- Cost forecasting and monitoring set up to fulfil b and c

4.1 Programming and progressing

The PC thought it necessary because of the complexity of the project, with the diversity of the construction and equipping works involved, and the importance of ensuring that the works are executed within defined cost and time limitations, to necessitate the establishment of an effective time control system. Appendix 5 shows the flow chart of the time control system.

4.1.1 Programming

A skeleton network for the whole project programme was produced by the PC in year 1. The skeleton network showed target dates such as the tender dates of major contracts, the dates of award of such contracts and the date of commencement and finishing of the works.

A skeleton programme for each contract in the form of a simple network was prepared by the Engineer in consultation with the PCT. This programme was included in the tender documents. The programme showed the interfaces with other contracts in the form of sectional completion and target dates. When the contract was awarded, the contractor was required to provide the Engineer with a detailed programme for approval. This programme was drawn up in the form of a network, by the PCT.

After confirmation by the Contractor of the network's correspondence to the submitted programme, the network was then incorporated by the PCT's Senior Progress Engineer (SPE) into the skeleton project programme.

As more contracts were awarded, the skeleton project programme became a project programme.

The project programme reached in years 4 and 5 a maximum of about 50 current critical path networks representing in total approximately 8000 design, pre-tender, construction, manufacture installation and equipping activities. The activities were interfaced to show the controlling requirements in order to achieve the phase completions of the project.

Each network and the project programme were held on computer file (using the ICL Pert program) on the County Council's computer. Provision of a terminal within the PCT department enabled direct access to the computer to be made for the input and updating of progress data and the receipt of resulting printout information. The programmes were updated approximately every 8 weeks, based on the input information explained in 4.1.2a and for the reasons stated in 4.1.2b.

Computer analysis of programmes was used as a planning and coordination tool ie in confirming the inter-relationship between contracts and establishing target and sectional completion dates to be included in the contractual and other project programmes.

4.1.2 Progressing

Once a major contract had been awarded, it was found by the PCT that close monitoring of progress by manual methods could give a speedy and reliable indication of the status of the project and its component phases with only a minimum use of the computer.

A Input Information

This information was used for the updating of the computer programmes and for the manual monitoring of progress.

During the course of each contract, information was obtained by the progress engineers of the PCT. In the peak period there were 12 such engineers involved with the monitoring of ongoing contracts. Each progress engineer monitored a number of contracts of the same nature eg tunnels, stations, M & E etc. The information was collected by the following methods:

- i) Direct inspection of the works
- ii) Regular site meetings with the Engineer's site representative (RE). It was left to each RE's discretion to decide whether the contractor's representatives participated in the meetings
- iii) Turn-round documents. These documents were computer printouts sent by the PCT to the Engineer. They contained the project information for the "Engineer's" ongoing contracts for the following 12 weeks. The "Engineer" updated the information giving the current position of the contract programmes and returned them to the progress engineers. This cycle was completed, at the longest, within three weeks.

B Processing of information and immediate action by the PC

The immediate and local effects of any progress slips indicated in the input information were usually apparent.

Updates of the major contract networks were carried out manually at fortnightly intervals.

A computer update of the project programme was carried out by the PCT every eight weeks. Thus the effect on each contract of any slip could be examined and discussed with the Engineers. It was therefore possible to minimise or obviate the effect by early detection before the actual work was late and agree with Engineers on action required.

C Output information

Based on the updates of the major contract networks, a Project Status Report (PSP) was produced. The PSP indicated the current position on all the critical items, for all the disciplines of the project eg civil (M & E), and the required action.

The report was discussed during the MG meetings and was approved for issue to the Engineers.

At similar time intervals, a shorter report stating the main problems was forwarded to the Executive for project information.

4.2 Financial control

4.2.1 Budgeting

A. A detailed project budget at base prices was produced at the beginning of each financial year. The budget incorporated the latest contract values and estimates for future works.

The original cost estimate of the project was prepared by the PC, against broad headings and notional designs. For the production of a detailed project budget the areas and types of works had been coded into measurable units forming a code for accounts.

The coding system consisted of six digits. The first two digits, 90, formed the code number allocated to the whole project. The following two digits represent the geographical area of the works (location) and the remaining two, the type of works.

Cost could be related to costs quoted at a different base date or could be deflated to base prices using cost indices from the Department of Transport statistics. For estimates of future figures, the PCT estimated the indices with graphical methods, using the latest published indices.

B. A computer resource program was developed because of the importance of reasonably accurate forecasting of project cash flow for the Transport Policy and Programme in each financial year. The program's aim was to give cash flow analysis by transferring the cost information for all the major contracts of a number of major contracts to the computer.

Each programme was represented by a skeleton network of activities related to the detailed project network. The contract billed value was apportioned to each activity. Known or expected factors likely to affect the rate of spending were taken into account. Allowances were made for the lead time between the execution of the works and payments against the Engineer's certificates. Cash flows over the span of each individual contract and the whole span of the set of contracts, in monthly and quarterly payments, were obtained from these programmes. The original contract cash flow figures were stored so that they could be used for comparison with figures updated to take account of actual costs to date, variations, and any pro-

gramme slip to date.

The project's cash flow was produced in base prices, by combining:

- the computer produced cash flows for the major contracts
- manually prepared cash flows for the smaller contracts.

The same cash flow in out-turn values was also produced based on the modified contract cash flows, with the application of price and adjustment factors.

During the course of the project's construction, the actual out-turn value of costs at the end of each financial year was within $\pm 5\%$ of the forecast value. The variation was due to incorrect estimation of the inflation rates.

4.2.2 Control of costs

4.2.2.1 Administrative procedures

In order to fulfil principle C of para 4, the PC proposed, and the Executive agreed, that:

- a. every action which could result in an increase of expenditure whether planned (eg placing contracts) or unexpected (eg issue of variation orders) had to be authorised by the Executive
- b. the contingency money should be removed from the discretion of the Engineer for each contract and should be controlled by the Executive.

With these decisions in mind, one of the first tasks of the PCT was to produce, in consultation with the five Engineers, and in accordance with the Client's public status, a set of procedures for the

administration and control of contracts during tendering and construction.

A set of procedures contained in a document titled "Administration of Project Control" (APC) were issued to the Engineers in year 2. The issue of the APC was immediately followed by the circulation within the PTE of a comparable supporting document called "Project Contracts Internal Administration Procedures" (PCIAP).

The aim of the procedures was to ensure the correct degree of co-ordination, overall time control and monitoring of the Client's commitments, and to avoid the difficulties which would follow if the various Engineers had other than a uniform approach to numerous matters. (ADC)

In the preface of the ADC it was made clear that nothing in the procedures was intended or should be construed as interfering either with each Engineer's power and duties under the contracts.

The APC covered the following topics, separately for the contracts directly controlled by the PTE from those where private consultants had been named as Engineers:

- a. The form of the contract documents and the procedures to be followed during the tender period. All the contract documents had to be prepared by the Engineer four weeks before tender. They were approved and issued by the Executive.
- b. The procedures followed during the construction period in relation to contract interim accounts, variation orders, prime costs, provisional sums, supplies, dayworks, price variations,

claims, completion certificates, liquidated damages.

c. The contents of the project cost statements (PCS) which formed the main input information for the management of contingency money.

The PCIAP stated to whom the documents or forms contained in the APC, would be distributed within the various departments of the PCT. (Details are given in appendix 7).

4.2.2.2 Authority forms

It was stated in the APC that authority had to be obtained from the Executive before the Client was committed to any additional expenditure. Forms were specified for this. Applications on them for expenditure were submitted to the MG for approval before they were forwarded to the Executive. The forms were accompanied by the appropriate internal report prepared by the PCT, and where necessary, the recommendations of the Engineer.

There were four types of authority forms. Each one covered a different type of expenditure.

A. Authority to invite tenders

The draft set of drawings and other documents produced by the Engineer for invitations to tender were presented to the PCT's Chief Civil Engineer (CCE), (in the case of civil engineering contracts) or a member of his department. The contract time schedules were discussed with the PCT's Principal Liason/Programme Engineer (PLE) and his staff. The PCT's Cost Analysis Officer (CAO) was also consulted, in order to make sure that the new expenditure could be

accommodated within the budget.

Once the members of the PCT and the Engineer had finalised the documents, the PE produced a report or cover note on the Engineer's report. This, together with the authority form, (Exhibit 1) were forwarded to the PC. The form stated the selected list of tenderers, and the Engineer's pre-tender estimate, compared with the current budget estimate for the particular works. The PC presented the reports and the form to the MG during the biweekly meetings. Once the MG had approved the expenditure, the authority form had to be signed by one or more members of the Executive, depending on the size of the Expenditure.

The letter inviting tenders was signed by the Secretary of the PTE.

The contractors were allowed one month to bid. The tenders were sent to the PTE; On the closing date the member(s) of the Executive who had authorised the expenditure opened them. The tender offers were assessed by the Engineer. The Engineer then produced a report which was sent to the PC who forwarded it to the member of the PCT involved with the preparation of the tender.

B. Authority for expenditure

A form for authorising the placing of a contract (Exhibit 2) was prepared by the PCT member. The form contained the tender data and recommendations for the award of the contract.

The same procedure was followed as before. Together with the form, a formal letter drafted by the PE recommending the award was also

attached.

If the expenditure was approved by the MG, the Contractor was informed by the Engineer and a letter of acceptance was signed by the selected contractor and the Secretary of the Executive. The form of agreement was signed later.

C. Request to issue a Variation order

A request to vary the works, either at the Client's request or because the Engineer thought it necessary, was prepared by the Engineer and was submitted to the PC. The PC then forwarded it to the member of the PCT dealing with the contract.

The request with the authority form (exhibit 3) was presented to the MG by the PC. The form showed the addition or reduction in the contract value with the corresponding adjustment to the contingency available against that particular code. (See sub section 4.2.2.3, Control of contingency money).

Once it was approved by the MG, the form was forwarded to be signed by a number of the Executive members and it was then returned to the Engineer.

The same form was also used when a claim was settled between the contractor and the Engineer.

D. Provisional sums

The same procedure as C above was followed for the authorisation to use amounts of money against the Prime Cost provisional sums.

4.2.2.3 Control of contingency money.

The contingency money was under the Client's control and was used for problems which required additional expenditure not foreseen in the contracts.

In the early stages of construction, 10% of the estimated total cost of the project was added to the budgeting as contingency money. It was then allocated to each contract in proportion to value, but kept under the control of the MG. At the beginning of each financial year this money was reallocated by the MG based on recommendations by the PC.

The contingency was made up of three components:

- a. provisionally identified estimates of additional requirements
- b. estimates of possible claims
- c. the balance of available money, apportioned to each contract in proportion to value.

As the works proceeded, a and b diminished or were defined accurately and they thus became part of c.

The input information for the management of the contingency money was obtained from the Project Cost Statements (PCS) (exhibit 5). The PCS were standard forms produced by the PCT, and described in APC. They were filled in by the Engineer and submitted to the PC together with every interim payment certificate, but they were forwarded to the MG for approval. They were submitted on different dates each month for each contract, so that all the certificates from all contracts were submitted at the same time.

The PCS contained the following information, at base prices, for every item of that contract's B of Q.

- Estimate
- Approved tender estimate
- Contract price
- Approved variation to contract
- Present contract value
- Payments previously certified
- Current monthly cost
- Certified date
- Outstanding commitments
- Estimated cost to completion
- Indicated total costs
- Over/under expenditure
- Claims on account
- Retention
- Escalation
- Materials on site

Possible claims could be monitored through this form. From these statements, monthly examinations of the overall project costs on all current contracts were made by the CAO against the budget and adjustments made to the balance of money available for future works and to the pool of contingencies.

The information obtained from the PCS's was also used for the manual review of the budget and the production of cash flows.

4.2.2.4 Special provisions

In the early stages of the project, a detailed examination was made

of project wide insurance, a single facility on site for testing construction materials and for the direct purchase of reinforcing steel and other materials. These items were considered to save costs, reduce delay, and achieve standardisation throughout the project.

- a. By taking out a project wide insurance in Year 1 by the Client instead of requiring individual insurances by each contractor, it was estimated that £0.750 million has been saved in base prices.
- b. There was no local laboratory with sufficient capacity to handle the predicted peak load of construction material tests. Instead of expecting every Engineer to set up his own laboratory, the Executive appointed in Year 1 a firm of testing consultants. One central laboratory with satellite laboratories and a mobile staff as a service to the Client on each civil contract were set up in February in Year 3. The only involvement of the Client was on financial and staffing matters. This option was adopted because it was expected to result in full utilisation of testing resources, closer budget control and more uniform testing standards. Its total saving was estimated at £0.500 million in base prices.
- c. The Executive decided, on the PC's advice, to purchase the required reinforcing steel in bulk. This decision was based on buying at reasonable rates at an early stage and to obviate any possible delays during times of steel shortages. Two major purchases of 11000 and 4000 were made in Years 2 and 4. After purchase the steel was stored until required when it was cut, bent, and delivered to the site. Payment was made on delivery to store. The cost of steel preparation and site delivery was paid after the site constructor had made a check and the Engin-

eer had forwarded the relevant delivery note which was compared with the invoice received directly by the Executive from the supplier.

- d. For similar reasons as those mentioned above, architectural finishes (vitreous-enamel-coated steel wall panels and stove-enamel aluminium slatted ceilings) and overhead line components were directly purchased and stored by the Client. These items were issued free to the contractors for erection or installation when the Executive had received notification of the contractor's requirements.

Taking into account the total cost of administration by the Client of these supply contracts, the PC estimates that a probable total direct saving to the project by this was in the order of £1 million.

5. Causes of Delays

5.1 External influences

5.1.1 Government restraints

Due to the limit imposed on grant aid in Year 1 to 2, the start of the major tunnelling contract was delayed by approximately six months. The contract was finally awarded in October of Year 1.

The Government's embargo on the award of new contracts from May to December of Year 2 delayed the award of 10 contracts. This delay disrupted current inter-related contracts and resulted in their radical reprogramming.

5.1.2 Relationships with BR

- a. Unofficial union blacking of works occurred because of uncertainty of future employment. This blacking of works on or alongside BR land during Years 2 and 3 suspended one contract for three months and another for five, and delayed the start of new works. Also, denial of access delayed future contract preparation by several months.
- b. Due to the possibility of union action, the use of contractors by BR was not possible for track laying, signalling and other works required in areas of new or realigned track. Delays in these areas occurred from lack of resources and the priority BR had to give to other works in the region.
- c. For works by PTE contractors alongside operational lines, track possession and/or protection of personnel was required. Major difficulties were encountered in obtaining site possessions.

d. The rate of progress of the works when given possession of such areas was much less than expected, mainly due to BR's lack of look out men and supervisors. The programme of equipping works was also affected mainly by the limited availability of works' locomotives and crews.

5.2 Site difficulties

Many of the site difficulties encountered in construction and equipping on individual contracts and requiring the granting of time extensions were overshadowed by the effects of the problems given above.

Some of the major difficulties on sites were the following:

5.2.1 Planning approval

Difficulties in obtaining Planning Approval for proposed works in certain areas caused some delays in the preparation of contracts.

5.2.2 Land entry

Legal difficulties in gaining right of access into working sites or to allow certain tunnelling works delayed the progress of works in certain areas.

5.2.3 Technical problems

Ground conditions affected the piling protection for building of one of the underground stations. In the same station, problems in keeping the traffic flowing were also encountered, and thus large extensions of time had to be granted.

5.2.3 Rolling stock

Extensions of time have been granted on this large equipping contract for a number of delays. Two examples of the causes of such delays are industrial disputes which affected manufacture and the late initial approval by the Executive of some major sub-contract items. None of these delays had an effect on the operation of the project.

5.2.5 Railway station

A part of a railway station had to be dismantled and rebuilt in order to provide an adequate foundation above the future platform enlargements. Agreement was reached with BR on the principles of the proposed scheme, but prolonged delay was experienced in obtaining rail union agreement to the required transfer of staff from offices in the affected part into refurbished accommodation.

6. Effectiveness of the Cost Control System

6.1 Assessment of design and management costs

The costs of design and management, expressed as percentages of the total project's cost in base prices, are estimated as follows:

Design	3.74%
Supervision	3.71%
Project Coordination	0.67%
Client's administration	<u>2.21%</u>
TOTAL	<u>9.93%</u>

6.2 Problems in relation to the management organisation and the implementation of the cost control system

- a. The Client, from the initial stages of the construction phase, attempted to apply to the BR works procedures similar to his own. As this did not prove possible, the Client and BR agreed in Year 6 that a working party should be set up and establish principles for cost control. This was carried out and a works agreement on an overall budget of £16.7 million in base prices, was negotiated between the Client and BR.
- b. The Executive had to authorise all the variations, minor or major, before they were issued by the Engineer. In some cases variations were issued by the Engineer before the Executive's authority was obtained, either because the variations were required quickly if the pace of the works was not to slow down,

or because, mainly due to the work overload, to obtain the authority took longer than expected. In such cases the Executive's authority was obtained in retrospect.

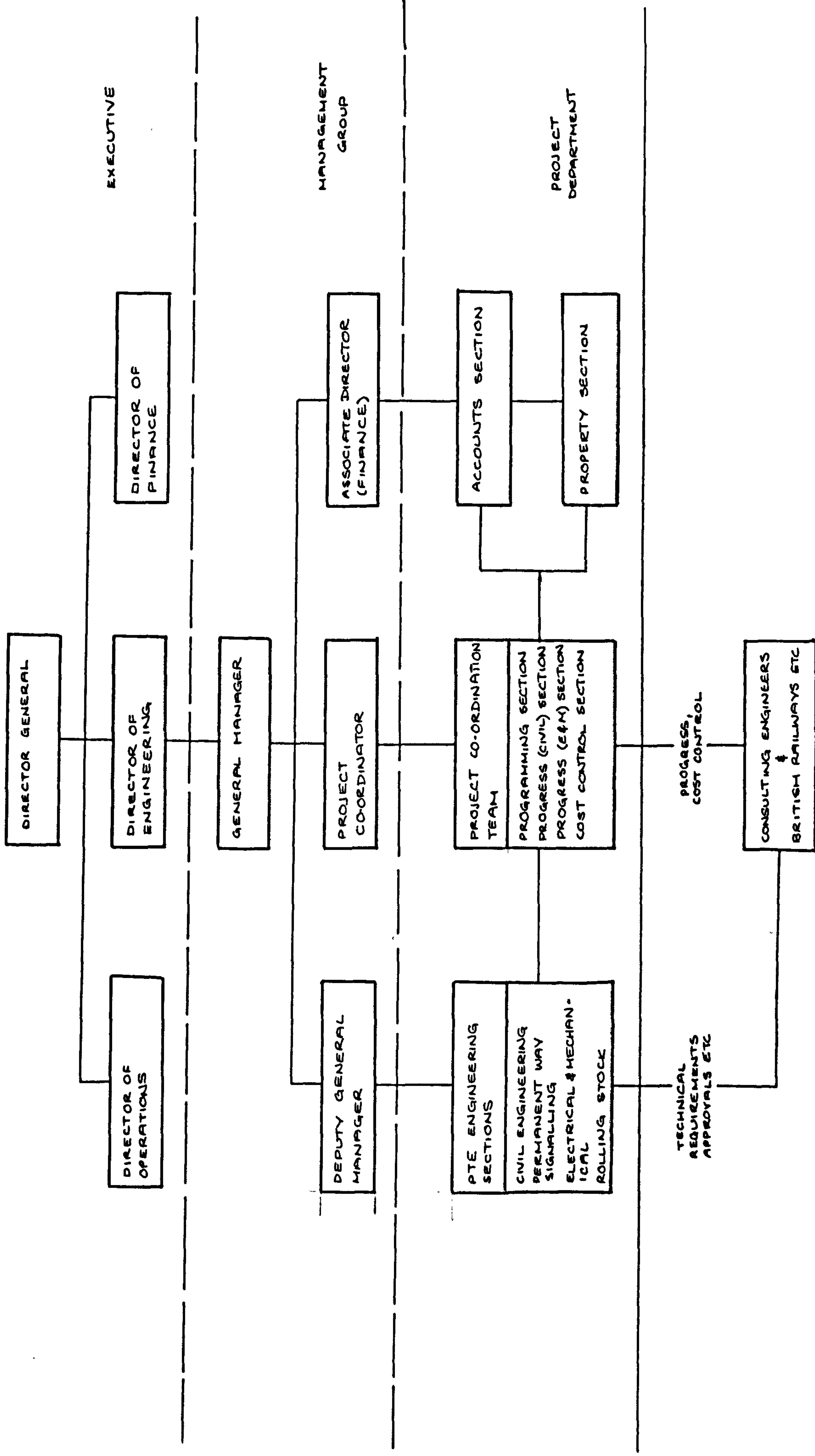
6.3 PC's improvement recommendations for future projects

- a. Labour relations expertise within the PCT would have been worthwhile in view of the many problems on that account.
- b. The use of micro computers and word processors will alleviate a lot of the work from the MT members which would otherwise have to be done manually.

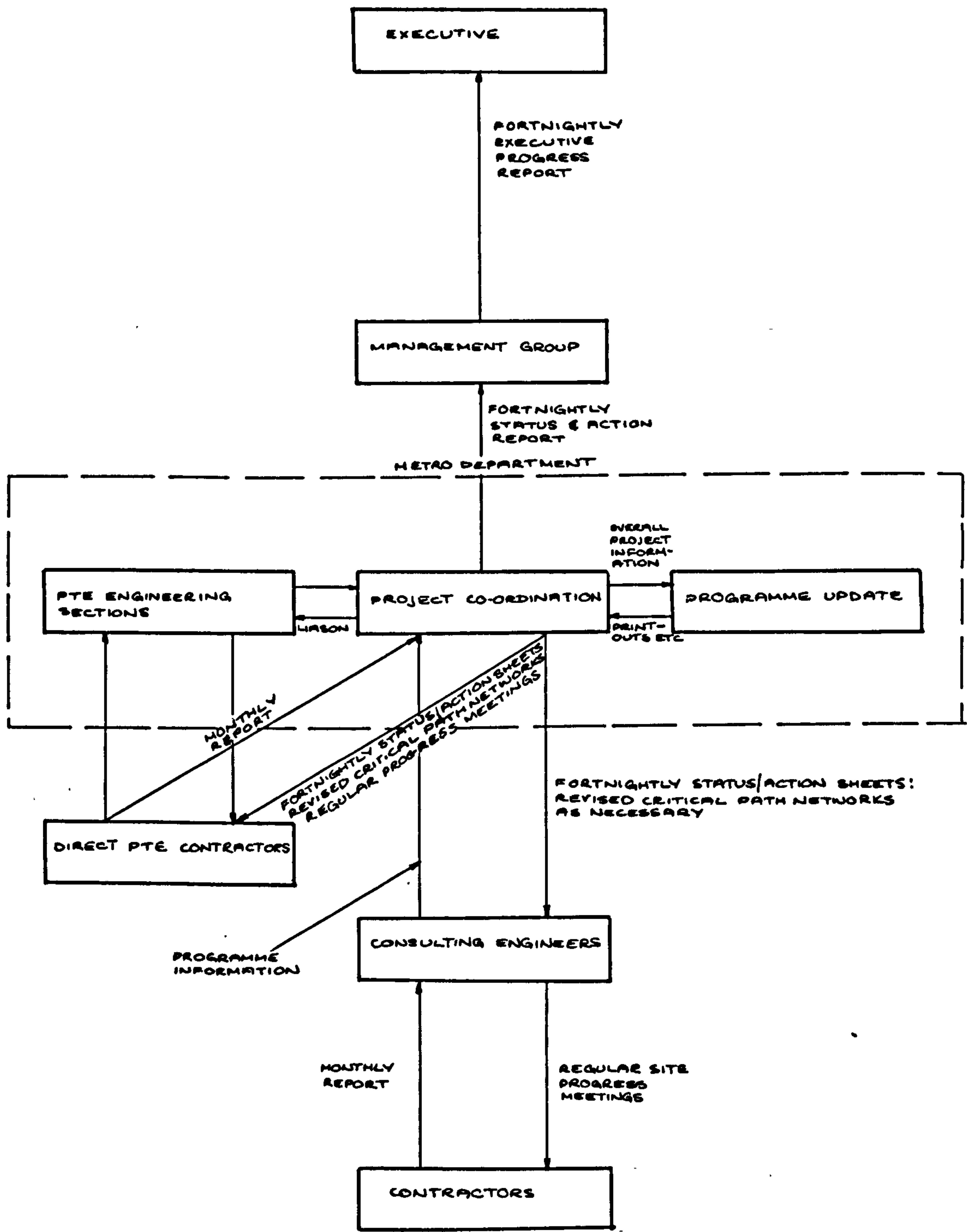
ANNUAL & CUMMULATIVE EXPENDITURE

FINANCIAL YEAR	ACTUAL												ESTIMATED			
	0 / 1	1 / 2	2 / 3	3 / 4	4 / 5	5 / 6	6 / 7	7 / 8	8 / 9	9 / 10	10 / 11	11 / 12				
CIVIL WORKS	1.1	4.4	12.4	13.6	20.4	16.6	12.5	8.7	8.0	5.6	4.2	0.9				
	1.1	5.5	17.9	31.5	51.9	68.5	81.0	89.7	97.7	103.3	107.5	108.4				
	—	—	—	—	—	—	—	—	—	—	—	—				
EQUIPPING WORKS	—	—	0.1	0.3	7.1	11.8	10.0	7.8	3.6	2.5	1.9	0.4				
	—	—	0.1	0.4	7.5	19.3	29.3	37.1	40.7	43.2	45.1	45.5				
	—	—	—	—	—	—	—	—	—	—	—	—				
OTHERS	0.5	2.0	3.0	2.3	2.6	2.0	1.6	1.7	0.9	0.6	0.5	0.1				
	0.5	2.5	5.5	7.8	10.4	12.4	14.0	15.7	16.6	17.2	17.7	17.8				
	—	—	—	—	—	—	—	—	—	—	—	—				
OVERALL	1.6	6.4	15.5	16.2	30.1	30.4	24.1	18.2	12.5	8.7	6.6	1.4				
	1.6	8.0	23.5	39.7	69.8	100.2	124.3	142.5	155.0	163.7	170.3	171.7				
	—	—	—	—	—	—	—	—	—	—	—	—				

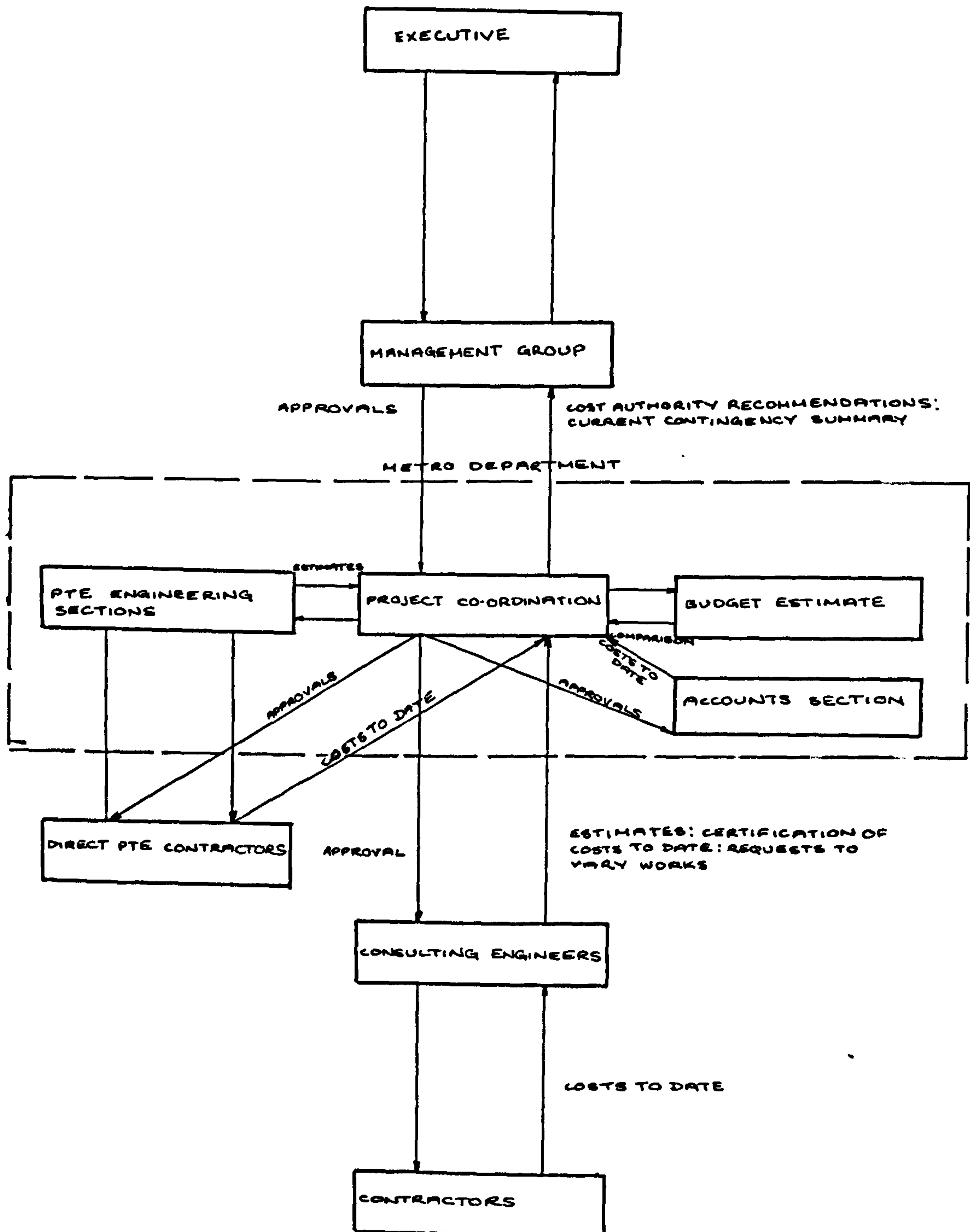
PROJECT'S MANAGEMENT ORGANISATION CHART



PROGRESS CONTROL FLOW CHART



FINANCIAL CONTROL FLOW CHART



ACTION

ACTION		SECTIONS						OFFICER			COMMENTS
		PC	CCE	ESM	FC	CAO	SPE	PE	SAA	SA	
APPENDIX 7.1											
A. PREPARATION OF TENDER DOCUMENTS											
1. ALL THE DRAFT TENDER DOCUMENTS PRODUCED BY THE ENGINEERS ARE TO BE FORWARDED TO											
2. EXAMINATION OF CIVIL CONTRACTS											
- C OF C											
- SPECIFICATIONS											
- B OF Q											
3. EXAMINATION OF M&E CONTRACTS											
- C OF C											
- SPECIFICATIONS											
- SCHEDULES , B OF Q ETC											
B. AUTHORITY TO TENDER											
1. OBTAIN THE PRE-TENDER ESTIMATE, & TENDER LIST FROM ENGINEER											
2. PREPARATION OF AUTHORITY FORM BEFORE IT IS SUBMITTED TO MG.											
- COMPLETE FINANCIAL COMPARISON TO BUDGET USING PRE-TENDER ESTIMATE											
- INITIATE & COMPLETE BASIC FORM REPORT											
- PREPARE, AS NECESSARY, MG REPORT TO EXECUTIVE											

ACTION

ACTION	SECTIONS					OFFICER				
	PC	CCE	ESM	FC	CAO	SPE	PE	SAA	SA	
<ul style="list-style-type: none"> - ORIGINAL CONTRACT REMAINS WITH SECRETARY - ONE COPY TO HEAD OF SECTION - ONE COPY TO PE - ONE COPY TO PC - ONE COPY TO DOCUMENTS LIBRARY 	*					*				PC. SPE
<p>6. CONTRACT INTERIM ACCOUNTS</p> <ol style="list-style-type: none"> ENGINEER SUBMITS CERTIFICATE AFTER ENTERING IN THE CERTIFICATE FILE, FIRST COPY WAS HELD BY THE FINANCE DEPT PAYMENT WAS MADE BY THE 28TH DAY FROM THE RECEIPT BY THE RESIDENT ENGINEER, AFTER THE CERTIFICATE WAS CIRCULATED AS BELOW <ul style="list-style-type: none"> - THE ORIGINAL WAS CIRCULATED TO THE FC, CCE OR ESM & APPROPRIATE PE FOR INITIALING BY PE & SIGNING BY FC, CCE OR ESM IN THE STAMPED BOX SECTION. IT WAS RETURNED TO THE FC - THE SECOND COPY WAS PASSED TO THE PC FOR EXAMINATION BY THE CAO, FOR COMPLIANCE WITH THE EXECUTIVE'S ADMINISTRATIVE REQUIREMENTS & FOR RECORDING THE CASH FLOW OF THE CONTRACT - ANY COMMENTS, QUERIES FROM THE OFFICERS OF THE P.C.T WERE REFERRED TO THE ENGINEERS 								*		SAA
									*	SA
		*	*	*			*	*		FC/CCE OR ESM
		*	*	*			*	*		FC/CCE OR ESM
	*				*					PC. CAO

FC/CCE OR ESM
SAA
PE

ACTION	SECTIONS						OFFICER			
	PC	CCE	ESM	FC	CAO	SPE	PE	SAA	SA	
J. <u>PRIME COSTS (PCs) & PROVISIONAL SUMS (PSs)</u>										
1. REQUESTS TO INCUR EXPENDITURE AGAINST PC'S & PS'S WERE CHECKED & APPROVED AS FOR VO'S, EXCEPT THAT AN "AUTHORITY FORM" WAS NOT REQUIRED UNLESS THE EXPENDITURE PROPOSED AGAINST THE SUM IN THE CONTRACT WAS TO BE EXCEEDED	*	*	*		*		*			CCE OR ESM/PC PE/CAO
2. A CHECK WAS MADE TO ENSURE THAT ALL THE COPY INVOICES FOR EXPENDITURE AGAINST THESE SUMS ACCOMPANIED THE VALUATION	*			*	*				*	PC/FC CAO/SA
K. <u>RESIDENT ENGINEER'S SITE ACCOMMODATION ETC</u>										
PC'S & PSs AGAINST THE RE'S SITE SET UP WERE TO BE SUBMITTED FOR AGREEMENT PRIOR TO TENDER. IF NECESSARY, REFERENCE WAS MADE TO MG FOR APPROVAL	*	*	*		*		*			CCE OR ESM/PC PE/CAO
L. <u>DAYWORKS</u>										
DAYWORK SHEETS WERE CHECKED & RETAINED FOR AUDIT PURPOSES	*			*	*				*	PC/FC CAO/SA
M. <u>PRICE VARIATIONS</u>										
ALL PAYMENTS AGAINST PRICE VARIATIONS WERE CHECKED	*			*	*				*	PC/FC CAO/SA

OFFICER

SECTIONS

ACTION

PC	CCE	ESH	FC	CAO	SPE	PE	SAA	SA
----	-----	-----	----	-----	-----	----	-----	----

R. CONSULTANT FEES

ALL ACCOUNTS WERE ALLOCATED IN DETAIL TO CODE
OF ACCOUNT NUMBERS & WERE CHECKED REGULARLY
AGAINST BUDGET ALLOWANCE

FC/CCE SAA
OR ESM/PC OR CAO

*

*

*

*

*

*

TEXT BOUND INTO THE SPINE

Account Code

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PASSENGER TRANSPORT EXECUTIVE

METRO

Ref. No.

T

AUTHORITY TO INVITE TENDERS/QUOTATIONS

197

Management Group Meeting _____ 197
is requested to invite tenders for the works described below

Works	
n of Works	

Tenderers	
Name	Address

<u>Expenditure</u>	Final Estimate	Budget Provision at Nov. 197	C <u>Cumulative Control</u>	Actual	Budget Provision
	£	£		£	£
prices			Value of Works/Goods:—		
Expenditure			Previously Authorised		
19 — 19			As recommended above		
19 — 19			Total Authorisation to date		
19 — 19			Balance available		
19 — 19					

Recommended that the above mentioned be invited to tender Comments: —
Engineer _____ Date _____ 197
Senior Accountant _____ Date _____ 197

Contract commentary

Project Co-ordinator _____ Date _____ 197
referred in accordance with delegated powers
led for approval by the Executive
Project Manager _____ Date _____ 197
Financial Controller _____ Date _____ 197
by the Executive per minute _____
or further comment _____
Secretary _____ Date _____ 197

Metro

Account Code

--	--	--	--

AUTHORITY FOR EXPENDITURE

Ref. No.

E

Authority to tender Ref. No.

--

..... 198.....

Management Group. Meeting 198

is requested to incur the expenditure described below.

PTE M536

Works

on of Works

Quotations received

Name	Amount	Acceptance Recommended

f Expenditure

C

Cumulative Control

	As per Rec. Tender £	Budget or Programme £		Actual £	Budget Provision £
— 19			Value of Works/Goods:—		
— 19			Previously Authorised		
— 19			As recommended above		
— 19			Total authorisation to date		
— 19			Balance available		
Commencement					
Completion					

re proposed expenditure is submitted in accordance with Standing Orders and Financial Regulations of the Executive and is
d for acceptance. Comments:—

Engineer Date 198

Senior Accountant Date 198

e/Contract Commentary

d/Deferred in accordance with delegated powers

ended for approval by the Executive

ed by the Executive per min.

ed for further comment

Project Co-ordinator Date 198

Project Manager Date 198

Financial Controller Date 198

--

--

Secretary Date 198

Account Code

--	--	--	--

METRO

AUTHORITY TO INCUR OVERSPENDING AND
ACCEPT VARIATION TO WORKS

Ref. No.

V

197

Authority to tender Ref. No.

Authority for Expenditure Ref. No.

Management Group Meeting 197
requested to incur additional expenditure/vary the works

PTE M538

Works	
or/Supplier	
on of Works	

ation	£	C Cumulative Control	Actual £	Budget Provision £
usly Authorised		Value of Works/Goods:—		
ending/Variation		Previously Authorised		
Submitted		As recommended above		
d Total Expenditure		Total Authorisation to date		
		Balance available		

or overspending/variation	
Engineer	Date 197
Senior Accountant	Date 197

/Contract Commentary	
----------------------	--

Deferred in accordance with delegated powers
ded for approval by the Executive

l by the Executive per minute
for further comment

Project Co-ordinator Date 197

Project Manager Date 197

Financial Controller Date 197

Secretary Date 197

Metro

Account code

ORITY TO IMPLEMENT AMOUNTS PROVIDED
AGAINST PROVISIONAL SUMS

Ref. No. P

Bill of Quantity
Ref. No.

Management Group Meeting 197

is requested to implement provisional sums contained in the contract.

Works		
tion of Works		
ctor		
ions Received		
Name	Amount	Acceptance Recommended

onal sum authorised in main contract(E)	Contract base date	Nov. 75 Prices
onal sum requested previously:		
quest:		
available		

for expenditure		
Engineer	Date	197
Senior Accountant	Date	197

me/Contract Commentary	Project Co-ordinator	Date	197
ed/Deferred in accordance with delegated powers	Project Manager	Date	197
ended for approval by the Executive	Financial Controller	Date	197
ved by the Executive per minute	Secretary	Date	197
red for further comment			

PROJECT C

The project consisted of the extension and extensive refurbishment of the terminal building of a regional airport in the UK.

CONTENTS

List of Abbreviations Used

1. Project
2. Owner Client
3. Management Organization
4. Contract Control System
5. Causes of delays and cost increases
6. Effectiveness of the Control System
7. Potential Improvements to Project Control suggested by the RE

This report is based upon the discussions with the Resident Engineer and Quantity Surveyor.

This draft is not yet agreed with the Engineer.

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This draft is not yet agreed with the Engineer.

ABBREVIATIONS USED

SPECIAL TO THIS REPORT

Client	Joint Committee of representatives from a Metropolitan and two County Councils
Authority	Airport Authority
E	Firm of Consulting Engineers
AD	Airport Director
OD	Operations Director
FD	Financial Director
DT	Design Team
Users	Commercial firms using areas of the terminal to promote their products or sell their services
Additional Approvals	VO's issued at Authority's initiative
SO's other instruction	VO's issued at SO's or RE's initiative

STANDARD ABBREVIATIONS

SO	Supervising Officer named in the Contract
RE	SO's representative on site
QS	Site Quantity Surveyor
C of C	Conditions of Contract
JCT	Joint Contracts Tribunal
B of Q	Bill of Quantities
VO	Variation orders from the SO to the Contractor
PC	Prime Cost sums

PROJECT C1. Project1.1 Purpose of the project

The purpose of the project was twofold:

- a. To improve the infrastructure of the region by providing an airport capable of coping with the growth of international flights well into the 1990's. Domestic traffic had decreased but the growing international traffic needed facilities to suit much greater numbers of passengers per plane; an increase in lounge, customs, catering, security and administrative services was therefore necessary.
- b. To increase the airport's revenue from the commercial enterprises using the facilities of the terminal, either to promote or sell products or services to the customers. The airport had been operating on the site since the thirties, but it was not until the fifties when passenger traffic started to be significant. It was then decided to replace the wooden huts with proper buildings.

The terminal was completed in the 60's and it was designed to cater for a standard busy rate of 650 passenger movement per hour. That design basis was satisfactory until the early 70's when the international to domestic passenger ratio was 30 : 70. As this ratio changed to 50 : 50 in the second half of the seventies, it became obvious that the existing facilities were not adequate.

The Government's White Paper on airport policy published in the

mid-seventies concluded that the airport should develop as a 'Category B' regional airport. i.e. provide services for a network of short-haul schedule international services and a significant range of charter and domestic services.

1.2 Technical description

When the extension was completed, the 8,600 m² total area of the existing terminal facilities was increased by 50%.

The existing terminal consisted of four levels with the following functions:

- a. The apron level where the baggage handling areas and the loose support facilities were located.
- b. The concourse level, where the departing and arriving passengers were processed.
- c. The amenities level (top floor) which contained the passenger amenities and the administrative offices.
- d. Roof level which provides public viewing facilities and buffet as well as the main plant rooms.

1.2.1 Description of new works

The layout of the extended terminal is shown in plans 1, 2 and 3 in appendix 1.

The main new work was:

- Extending the terminal building on the airside of the whole length of the building, together with a three bay extension on the North side at all levels.
- Constructing a new pier with two gate rooms and four staircases two on the North and two on the South side of the building.

Within the building the layout and facilities were changed thus:

A. On the concourse level

- The check in facilities were reorganized to permit greater queuing space. The number of desks was increased and 3 baggage conveyors were added, as a result of the new desk arrangement.
- The domestic and international lounges were increased in size.
- The domestic arrivals facilities were enlarged and the single conveyor was replaced by a carousel to improve baggage claim.
- The international areas were also increased and replanned. Airside passenger movement facilities were enlarged. The new facilities incorporated an airside passenger distribution corridor, a central area containing the search control immigration offices and a health check.
- Access to the apron from the two new gaterooms was by means of staircases. Future extensions of the pier was possible.

B. On the amenities level

- The buffet was moved from the concourse to the top floor, and was enlarged. The restaurant was increased in size. Both the cocktail lounge and VIP Suite were also enlarged. In addition to the VIP Suite, a CIP Suite was provided for the use of the Airlines and others using the airport, as an entertainmmnet Suite for important passengers.
- The airport administration suite was enlarged. An overnight suite was provided and the boardroom which could also be used by visitors, was doubled in size.

C. On the Apron level

- The baggage handling area was enlarged.
- More offices and toilet facilities were provided.

D. Root level.

- To retain the buffet facilities and extend the main public viewing area.

E. Fire Escapes

- To increase the number of fire escapes to four to serve levels 1 & 2 and two escapes to serve the roof.

1.2.2 Stages of the works

It was imperative that the terminal continued to function with a minimum of disruption during the extensions and refurbishment work. The works were therefore staged in four consecutive stages. Each stage was defined in the tender documents. The staging of the works was slightly altered during the construction phase for the reasons explained in paragraph 5.1.2. Thus some work areas allocated to stage 2 were offered to the contractor in advance of the completion of stage 1.

The work areas covered in each stage, as they were actually carried out, are shown in appendix 1 plans 1, 2, 3.

- During stage 1 all three levels were extended and refurbished to the North by 20m and to the East by 12.5m (appendix 1, areas marked as Ia).

In the North extension on the concourse level, the domestic reclaim conveyor belt, a shop, a domestic departure lounge and the entry and

exit aprons (1c) were fitted. On the amenities level the CIP suite (entertainment suite for important passengers), the toilet facilities and a snack bar were also completed.

In the East extension on the concourse level the immigration facilities and the VIP suite and the cocktail lounge on the amenities level were fitted. The enlargement of the cocktail lounge was brought forward from stage 2.

The roof extension proceeded to the north and east as defined by work at other levels.

Two new fire escapes were constructed on the North side of the terminal (1a).

- During stage 2, the International departure lounge and the search rooms were extended on the concourse level and the pier and gate room 11 were constructed.

On the amenities level the restaurant was extended.

- During stage 3, the old pier was demolished and gate room 2 was built in its place, together with two escape staircases on the south side.

The check in areas on the concourse level (3c) were also equipped and the entry and exit patios (3c) were completed.

- During stage 4, the international reclaim area was equipped.

1.3 Time schedules

One contractor was appointed for the completion of the four stages.

The contract period was for 27 months.

Stage 1 commenced in July of year 1 and was completed on the 15th July of year 2.

The second stage was completed on the 30th February of year 3.

The third and fourth stages were completed at the end of September and the 28th of November of year 3.

A three week time extension was awarded to the Contractor mainly due to delays, explained in paragraph 5.1.2, during stage 1.

The project was observed by us during its third and fourth stages.

1.4 Costs

At the tender stage, the cost estimates of the project were:

							(in millions)
Total cost .. .. .	..	..	..	..	..	..	£ 6.982
Value of works .. .. .	..	..	..	..	..	..	£ 5.458
Contingency and dayworks .. .. .	..	..	..	..	..	..	£ 0.124
Total in base prices .. .. .	..	..	..	..	..	..	£ 5.582
Price fluctuations .. .. .	..	..	..	..	..	..	£ 1.400

The final costs of the project in December of year 3, i.e. one month after completion of the project, were:

Total cost	£ 6.728
Value of works in base prices (July year 1)	£ 5.233
Value of additional works in base prices ..	£ 0.390
Contingencies and dayworks in base prices including £0.070 million in settled claims	£ 0.330 (+ 160%)
Total in base prices	£ 5.953 (+ 6%)
Price fluctuations	£ 0.775 (- 45%)
Outstanding contractual claims	£ 0.110
Amount certified to contractor	£ 6.617

The contractor has submitted claims in excess of the above figure.

A more detailed analysis of the costs appears in table 1 of appendix 2.

2. Owner Client

2.1 Clients nature

The Owner of the project was a consortium of two County Councils and a metropolitan County Council represented by a Joint Committee responsible for the operation and development of the project.

The Joint Committee acted as the Client during the design and construction phases of the project. The Committee consisted of a number of elected councillors, one of whom was the Chairman, a Treasurer and the Airport Director (AD) of the Airport Authority (Authority).

The AD and his senior staff, i.e. the Operations Director (OD) and the Finance Director (FD) were employed by the Client and they were responsible for the operation of the Airport.

After the Client was formed in the early sixties, one of his first acts was to appoint and retain a firm of Consulting Engineers (E) or project managers and planners for the development of the Airport.

E reported directly to the Client. On the detailing and phasing of the works E worked closely with the AD, OD and FD.

2.2 Sources of finance for the project

The finance of the project was provided by the participating Councils and a grant from the Central Government.

At the beginning of the construction phase the sum of £6.982 million was reserved by the Client for the project. This sum was based on

the Contractor's revised tender offer of £5.375 million an estimated allowance of £1.4 million for price fluctuations, and the sum of £0.225 million for works not included in the contract but which were carried out by the Contractor (see appendix 2 for more details about costs).

2.3 Client's expectations

During the design and construction phases the Client and the AD were faced with conflicting priorities in choosing between the cost-time-performance interdependent variables. The conflict was due to the project's purposes, its sources of finance and the fact that it had to remain operational throughout the construction phase.

- a. The project's nature as a public project, because it was financed by public funds and one of its aims was to improve the regional infrastructure, made the control of the cost variable more important.
- b. The restricted work areas offered to the contractor affected the contract sum because of the:
 - extensive temporary works were necessary i.e. internal dustproof hoardings
 - risks involved and the longer time period required for the completion of the works
 - number of revaluations due to changes of phases for unforeseen or overlooked in the design reasons
 - uncertainties in relation to his anticipated cash flow.
- c. The project's commercial purpose made it vulnerable to the changes of market trends, because the balance of the variables was aimed at maximizing the total revenue. Thus an additional expenditure for the improvement of quality, (e.g. improve finishes), or to provide more floor area, would have been accep-

table, provided that it was cost-effective.

The Client placed great emphasis on the control of costs. Thus some works were omitted from the contract soon after the tenders were submitted but before the contract's award at the Client's request. The objective was to reduce its total capital value in order to keep the total estimated cost in outturn prices within budget. A budget in outturn prices, based on the pretender estimates produced by the DT and an estimated sum for price fluctuations was reserved by the Client for the project, and placed at the disposal of the AD.

The Authority being responsible for the operation of the airport, the commercial side and the improvement of finishes or other aspects which were likely to improve the operations of the airport were of a great importance. A few months after the omission of the works, the AD and the Consultant were successful in persuading the Client to raise the budget in order to reintroduce the omitted works. The following as compared to the estimated, inflation rates helped them in their effort).

The standard and quantity of some finishes, services etc were included in the B od Q in the form of PC and Provisional sums, in order to be determined during construction depending on the available money.

A number of additional works requested by the Authority were also accommodated as it became obvious that the actual price fluctuations were going to be less than £1.4 million.

2.4 Attitude of Client towards the project during the construction

The Client's involvement with the project, provided that there was no overrun of the budget was limited to:

- checking that payment's were made according to the C of C and
- securing that his standard procedures for the administration

of public works were observed.

During the construction phase the Client received a financial report from E every three months.

The Client had also to be informed before a decision likely to have a significant effect on the budget was taken.

The final accounts were checked by the Client's auditor in order to ensure that payments were made in accordance with the C of C.

The procedures followed for the selection of the contractor and his nominated sub-contractors, and the choice of type of contract were influenced by the Client's nature and expectations.

The AD and his senior staff were actively involved with the phasing and rephasing of the works and with the initiation of additional works. The AD and his senior staff were also informed by E about major changes to the design which were likely to increase the cost of the works.

The administration of the contingencies and dayworks included in the contract was left to the discretion of E.

3. Managemnet Organization

3.1 Management structure (shown in appendix 3)

A fee was paid to E by the Client, for his management services during the design and construction phases and the cost of the design.

A senior partner of the firm was put in charge of the management of the project.

In the C of C with the Contractor, the partner appears as the Supervising Officer (SO). The SO is assisted by the Project Manager (PM) who is also a member of the same firm. Both the SO and PM are based in their firm's HQ some 280 miles away from the project's location.

During the design stage a design team (DT) was set up by the SO. The SO was free to choose the DT's members either from within his firm, or from other firms. Architectural design and Quantity Surveying were carried out by two firms independent of the SO's firm. Each of these firms appointed one of their senior Partners to be in direct communication with the SO. Structural engineering design was carried out by the SO's firm. The M & E parts of the design were specified by the SO firm's M & E design staff, and were then designed by the M & E nominated sub-contractor. The M & E services were included in the B of Q as PC sums.

The Resident Engineer (RE) and his staff were appointed by the SO.

The site Quantity Surveyor (QS) was appointed by the firm of Quantity Surveyors.

All the site staff, apart from the Deputy RE who was a member of the E's staff, were employed for this project.

The site staff were appointed soon after the award of the contract.

3.2 Delegation of authority to the members of the Management Team (MT) and links of communications between the members

The Client, the AD and SO met once every three months. During these meetings the Client was informed of the committed costs as well as the estimated costs of the outstanding works. Members of the Committee could question any expenditure which had occurred or decisions which committed the Client to additional expenditure.

The AD had direct access to the Chairman and he usually consulted him before he requested the SO to issue a VO for additional works.

The AD, OD and FD were kept informed by the SO, PM, RE and QS about the progress of the works and outstanding payments.

The OD was concerned with keeping the airport operational throughout the construction phase. The RE consulted him before he instructed any changes to the phasing of the works, in order to ensure that the proposed changes did not interfere with the terminals operation.

The OD also acted as a liaison between the RE and AD. All the requests from the AD for additional works were communicated to the RE through the OD.

During stage 1 the SO issued all the VO's which could involve an increase of the expenditure by more than £10,000. In the following

stages the administration of the contingency and dayworks sum of £0.124 million was left at the discretion of the RE. The SO was consulted however before VO's with a higher than £10,000 cost implication were issued against the 'Additional Approvals'.

The SO signed the completion certificates, certified the interim and final payments, granted extension for period of completion and settled claims. The SO was also consulted by the PM and RE before any rephasing of the works was proposed to the OD. Once any such change was agreed with the OD, a VO was issued by the SO.

The PM acted as the SO's advisor and as a coordinator between the RE and DT.

As soon as the RE was employed the contractor was informed of the powers delegated to him, by the SO. The main function of the RE was to supervise the Contractor in order to:

- complete the project within the contractual time
- keep the project's final cost within the budget
- achieve the quality standards specified in the design and the specification documents. In the case of sub-standard works the RE informed the Contractor who then submitted his proposals for remedial works.

The QS's duties were to:

- a. produce interim valuations excluding the ME's works which were valued directly by the SO with the assistance of the M & E members of the DT as it is shown in appendix 3. The QS was notified of the amount to be included for the M & E works in the

interim payments. The role of the RE and his inspector for M & E works was limited to the technical supervision.

- b. calculate price fluctuations.
- c. remeasure the effect of VO's and produce them in the final amount.

At first the QS was not consulted before the issuing of VO's. The QS received the instruction at the same time as the Contractor and he then evaluated and recorded them.

Towards the end of stage 2 the procedure of issuing VO's against Additional Approvals changed because of the volume of the extra works requested. Thus, once additional works were requested by the AD, the QS produced, in consultation with the RE, an estimate of the anticipated direct and indirect (e.g. due to interference with the Contractor's ongoing works) costs.

The estimate was discussed between the RE & QS, and the OD and sometimes the AD. If the AD approved the extra expenditure then an instruction was issued by the RE. For changes with a high cost effect the AD discussed the matter with the Chairman of the Committee, and the RE consulted the Partner before an instruction for 'additional approval' was issued to the Contractor by the RE.

The SO's other instructions were first issued and then evaluated by the QS until the end of the project.

- d. produce a Financial Report every three months, which showed the current financial state in relation to the instructions issued.

3.3 Scope and type of contract

The Client agreed with the SO's recommendation that because of the project's complexity and size, it was more advantageous to include all the required works in one contract.

The C of C were drafted, at the Client's request, according to the Standard form JCT, with quantities, 1963 edition, July 1977 revision; with price fluctuations and sectional completion. The Client favoured this type of contract because it does not allow variations of the contract sum at base prices.

Clause 12 of the JCT C of C referring to the Clerk of Works was deleted and instead the RE was appointed. A list of six contractors was drawn by the SO and approved by the Client, out of the contractors who responded to the 'Invitation to tender'.

The lowest tenderer of the six preselected contractors was awarded the contract in year 1.

The Contractor was responsible for accidents to his workforce, accidents of third parties on the site and also damage to property and theft. He covered himself against those risks with an insurance policy for £2 million. The insurance policy also covered him against any disruption he could cause to the operation of the airport such as diversion of aeroplanes to other airports because of a power failure, he, or one of the nominated sub-contractors had caused.

Insurance in excess of £2 million was covered by the Client.

The Contractor was also responsible for the efficiency of the sub-contractors nominated by the SO.

The nominated sub-contractors had been appointed in order to carry out works for which PC sums had been included in the B of Q.

Examples of nominated sub-contractors were the contractor for M & E, the conveyor belts, the international bar in the passport control area, new windows and refurbishment of existing ones etc.

The Contract Conditions of those sub-contracts were prepared by the DT. In the sub-contract for the supply and installation of the conveyor belts, liquidated damages for delayed completion were not included. A penalty clause was not included because it was the sub-contractor's policy not to enter into contracts where a penalty clause was included in their C of C.

The sub-contractor was in a strong negotiating position because he had installed the conveyors in the existing building. The SO also felt that his workmanship was of a good standard and thus he recommended to the AD his nomination as a sub-contractor.

The M & E sub-contractor had been appointed by the SO and Client following direct negotiations, before the award of the contract.

The AD awarded some concession leases following competitive tendering to commercial firms. (Users). These leases allowed the User to use specified areas of the terminal to sell their products or their services. The AD had undertaken the obligation to provide supporting facilities for the tenderer's suppliers and subcontractors.

The Contractor had been informed by the SO that he would have to provide such supporting facilities but no specific items or quantities

had been included in the B of Q.

The C of C allowed for the execution of these works by other contractors within the areas allocated to the main contractor.

One example of such a lease was the case of a firm which was awarded the use of the snack bar areas on the amenities level.

The User selected the suppliers/contractors who were going to supply and install the necessary equipment. The Contractor had to provide electricity, gas, water outlets, after he was informed of the layout and capacity of the power supply water and gas mains etc. The Contractor also had to return and complete the floor and ceiling finishes after the User's suppliers/contractors had installed the catering equipment and display units.

4. Contract Control System

4.1 Planning

A. Time schedule

Soon after the appointment of the Contractor, the Agent produced a basic bar-chart showing the time span of groups of works to be carried out during each phase. The bar chart was based on the revised programme of works mentioned in note 2 of appendix 2, and the phase time periods quoted in the tender documents.

The reintroduction of the omitted works and the phase changes outdated the bar chart within a few months after its introduction. A planner had not been included in the Contractor's site staff. Separate bar chart programmes were produced by the Contractor's Agent at the beginning of each of the 4 phases of the contract. The target dates of these bar-charts were based on the information known at the time of production but were not updated as the works of the phase proceeded.

B. Bill of Quantities

Based on the B of Q and the phasing of the works proposed in the design of the QS derived:

- the contractual payment curve (in base prices)
- the contractual value curve (in current prices)

The purpose of these curves was twofold:

- i) to show the estimated cash flow in base and outturn prices to the end of the construction phase and
- ii) to be used as a monitoring tool in order to predict over/under expenditure by comparing the actual expenditure to the forecasted one.

The validity of the curves as planning or monitoring tools was soon

diminished because of the unreliability of the B of Q because of the deviations from the original design and method of construction during construction.

The curve of appendix 4 illustrates the difference between the estimated and actual expenditures.

4.2 Control of Costs

The Client's attitude and the C of C made the control of costs against budget important. Thus decisions to control time or quality were judged against cost.

The RE tried and succeeded in keeping the SO's other instructions within the contingency and daywork allowance.

In order to succeed in his task he relied on close operation with the QS, Agent and OD. During the first six months of the construction phase, the relationship between the RE and Agent was kept formal. Later on, as all the participants became more familiar with the project, a close working relationship was established among them, and quick decisions, which averted claims, could be taken.

The RE's task also became easier because the SO gradually allowed him to use the B of Q's contingency at his discretion.

A. Input information

Details of the progress of the works were gathered by the RE and his staff.

Financial information was produced by the QS. It was based on the valuation of the issued VO's and the interim valuations he proposed and recorded.

B. Monthly meetings

- Meetings took place between the RE, QS and the Contractor's Agent and QS in order to discuss the progress, the tackling of potential problems and find methods to avoid delays and possible disruption to the airport's operations. Informal links of communication also existed between the participants.

- The RE & QS had also monthly meetings with the OD and the FD. During these meetings the possible changes of the work stages were discussed, as well as the implication of changes requested by the Authority. A typed summary of the topics covered was produced after each meeting.

4.3 Reporting

4.3.1 Financial Report

The purpose of the Financial Report prepared by the QS was to inform the SO the AD and the Client of:

- the so-far committed costs against the tender price
- the updated estimated cost of the project. Besides its information purpose the report also served as an approval of the Client and of the recorded and forecasted expenditures.

The report was drafted every three months by the QS in consultation with the RE.

The report was drafted in a format supplied by the QS firm.

Topics contained in the report were:

i) a cover page showing:

- the total payments in base and outturn prices
- the additional approvals
- the balance of the adjustment of PC and Provisional sums and the estimated effect of SO's other instructions against the contingencies and dayworks allowed for in the B of Q.
- the estimated amount of CPA
- the expected claims
- the final contract cost in outturn prices

ii) tables containing:

- item by item description and cost of additional approvals
- detailed adjustment of PC sums
- detailed adjustment of Provisional sums
- description and cost of estimated effect of SO's other instructions.

The draft Financial Report was forwarded to the PM who discussed it with members of the DT before he forwarded it to the SO. The Financial Report in its final form was then forwarded to the AD and the Client's Treasurer.

The report was discussed in a meeting between the AD, FD, PM and the Client's Treasurer. (Step 4 of appendix 5). If it was approved a summary was forwarded to the Client which was discussed and approved during a meeting (Step 5).

The time required for the report to complete the above described cycle varied between 6 to 8 weeks. The way the report was circulated is shown in appendix 5.

4.3.2 Progress Report

The SO produced a progress report every three months, on the basis of information from the RE.

The report was circulated to the Authority and the Client (appendix 6) together with the Financial Report.

The report was presented to the Committee at each Committee meeting and formed part of the minutes.

5. Causes of Delays and Cost Increases

The time for the completion of the programme was extended by three weeks. The total increase of the contractor's tender offer, in base prices, was £0.774 million (Appendix2).

The main causes of delays and cost increases were due to:

- additional work ordered by the Authority
- the interference to the Contractor's programme caused by the nominated sub-contractors and the suppliers/contractors of the Users of the terminal facilities
- SO's other instructions and adjustment of PC and Provisional sum ie changes to the scope of the design initiated by the SO.

5.1 Changes ordered by the Client

The Client initiated changes of the design scope because of:

- The sources of finance of the project. The project's budget was susceptible to the changes of the national economic climate, which influenced the financial policies of the Government and of the Local Authorities.
- Changes in the project's commercial purpose, described below.

a. Financial Pressures

Because of the Client's condition that the project could only go ahead if the tender price was not higher than £5.3 million, before award of tender, the Contractor was informed that some of the works were going to be omitted, e.g. the gate room. An addendum B of Q was therefore prepared by the QS., which detailed these omissions. The Contractor was therefore awarded the contract for less works than he tendered for but based on the B of Q he priced before the omission of those works.

Four months later the Client decided to reintroduce the omitted works. The SO negotiated with the Contractor and it was agreed that the works would be carried out at the tendered rates, subject to price fluctuations. Fifty percent of the additional approval sum of £0.254 million is due to this reintroduction.

b. Commercial Pressures

I Interference to the Contractor caused by the Users and their suppliers/contractors (paragraph 3.3).

In the case of the User for the catering services, mentioned in paragraph 3.3 the Contractor's programme was initially disrupted because of delay in the supply of information concerning the lay out plans by the User.

The Contractor's programme was further interrupted due to delays in the installation of the User's equipment in the snack bar area, carried out during stage 1. (After the installation was completed, the Contractor had to return to the area to complete the floor and ceiling finishes).

The total delay to the Contractor during stage 1, because of the User and his suppliers/contractors, was estimated to be eight weeks. A three week extension was awarded to the Contractor at the end of stage 1, and the remaining five weeks were offset by allowing the Contractor to proceed with works of stage 2, during stage 1.

II Operators desks. The Authority, during phase 3, negotiated, without the SO's knowledge, the provision of a number of

information desks to holiday operators. These desks were to be located in the check-in area of the Concourse level.

The SO, the Architect and the RE felt that the queues forming in front of the proposed desks would interfere with the queues and the flow of the passengers as they check in, and during peak hours the check-in area would be congested. Instead they proposed that such desks should be located in the Amenities level.

Whilst this involved no delays to the contract it indicates the changes in use which were proposed during the contract period.

- III Duty Free Shop. The User wanted the duty free shop to be ready by the 1st of April, when traffic increases. The whole area and the shop were programmed to be handed over at a later date. The Contractor agreed to accelerate his work for the shop without additional costs to the Client.
- IV British Airways (BA). BA had been allocated a certain number of offices to rent. Due to the BA's reduction of staff many of these offices were never occupied. If this situation had become apparent during Phase 1 or 2, then the Authority would have asked the SO to change the use of this space area.
- V Customs and Immigration. The Customs and Immigration Service revised their specifications and requirements during the construction, and as a result, bigger spaces had to be provided, with alterations to M & E services.
- VI Advertising space. Advertisements are a considerable source of revenue. Once the demand for them was realised, the AD asked the SO to provide more spaces. This would have implied a VO and an additional cost because of the electric connections etc. The Authority was advised by the SO to place a direct contract,

such that an extension of the main contract was avoided.

An instruction had also to be issued to provide temporary electrification for all the adverts until the works in the area were finished. This meant an additional expenditure to the Client, which was balanced by revenue being received at an earlier date.

VII Signs. The Authority requested the replacement of the direction signs in the terminal by a different type. The RE contacted directly the nominated sub-contractor and requested him to quote a price for the supply and installation of the new signs. Once the quotation was found to be acceptable by the SO, the AD was asked to approve it and a direct order was placed.

5.2 Interferences of nominated sub-contractors/suppliers with the Contractor's programme

The nominated sub-contractors intereferred with the Contractor's programme by:

- causing delays in order to carry out remedial works ordered by the RE, as in the case of the M & E sub-contractor
- taking longer than it was allowed for in their contract to complete the installation. The conveyor belt sub-contract was such an example
- damaging the Contractor's works while they installed their equipment.

The coordination and control of the nominated sub-contractor for the conveyors was difficult because no damage clause had been included in the C of C for the reasons mentioned in sub-section 3.3.

The lack of the penalty clause made it difficult for the RE to exert pressure on the sub-contractor when his work progress was causing delays to the Contractor's programme.

5.3 Changes of the scope of the design initiated by the SO

- a. The RE issued 750 instructions, SO's other instructions, which amounted to the extra sum of approximately £0.126 million.

These instructions were issued in order to improve finishes, provide details overlooked in the design, or to carry out additional works requested by the Client.

The value of each instruction varied from a few hundred pounds to £10,000. Most were carried out at daywork rates.

- b. Changes to the scope of the four stages were deemed necessary, not only as a counter-balancing measure against the Contractor's possible claims but also because of the following reasons:
- When the work stages were arranged by the DT the commencement date was not known. When the contract was awarded and the works commenced, changes had to be made to the work sequence in order to minimise the interference of the works with the operations of the airport during the various seasons.
 - Minor details which had been overlooked in the design.
 - Some solutions which looked attractive on the drawing board ceased to be practical when the works were carried out.
- c. The duration of some activities had been under-estimated. For example, the time required for services such as telephone lines, gas and water mains etc. to be discontinued or removed, was larger than the DT had anticipated.

- d. Some problems were caused due to occasional breaks of communication, shown in appendix 3, of the MT. For example there had been some instances where some members of the DT concerned with finishes (selection of colour schemes, specifications of tiles etc.) approached directly and in some cases persuaded the AD to adopt their ideas without the RE's knowledge.

It would be difficult to quantify in monetary terms, the implications of such problems but they tended to cause confusion among the member of the MT.

- e. Some minor problems were caused due to the delay of information from the DT to the RE mainly concerning details of finishes of the VIP room, Board room etc. These delays however did not result in any claim, for costs or time extension.

5.4 Increases of PC and Provisional Sums

The PC and Provisional sums in the B of Q had been under-estimated for two reasons:

- The Authority did not specify its exact requirements at tender stage.
- The DT did not research the market, possibly due to lack of time.

Thus the PC's were estimated and were not based on actual offers by prospective sub-contractors.

6. Effectiveness of the Control System

6.1 Supervision cost

The total cost of supervision, excluding the QS's salary which was paid directly by the firm of QS's, was approximately £0.200 million.

The originally estimated supervision cost was £0.250 million.

6.2 Benefits from the Control System

The described control system served only as a cost recording system and not as a decision making tool, because of the following reasons:

- a. The B of Q could not be used as a tool for monitoring or forecasting costs against budget because:
 - the phasing of the works shown in the drawings was not correctly reflected in the B of Q
 - the considerable variation between the quantities contained in the B of Q and the actual finished works
 - the addendum B of Q produced after the award of the contract.
(Omission and reintroduction of works by provisional sums)
 - the changes of phases which changed the pattern of payments
 - the gross variations between the PC and provisional sums included in the B of Q and the accepted prices for these works
 - The number of additional works requested by the Authority which altered the scope of the design
 - the number of the SO's other instructions which were issued during the construction phase.
- b. The monitoring of the expenditure and the control of costs was difficult because of:
 - The SO's "other instructions" or the "additional approvals".

were issued without prior evaluation by the QS. (In the second year of construction the QS started to evaluate the additional approvals).

- The lack of damages clauses in the C of C of the suppliers/contractors of the Users made it difficult for the RE and his staff to motivate those contractors to complete their work on time.
- The evaluation of the M & E sub-contractor's interim and final payments and claims were not evaluated by the QS before they were approved.

c. There was no planner among the Contractor's site staff. Thus neither the overall nor the phase bar charts were updated as the works of each phase progressed.

It is the RE's opinion that even if the updating was carried out regularly it would not have been a substitute to the short term (i.e. plan the works a week in advance) planning and coordination of the works.

The method of planning used was successful because of:

- the close cooperation between the RE and Agent in identifying the critical activities and in trying to work out alternatives to overcome problems when they occurred.
- the willingness and ability of the AD to approve the proposed action swiftly even when additional costs were involved, or the OD to approve the replanning of work areas to be made available to the Contractor.

The lack of updated medium or longterm programmes was a problem

in so far that the RE was not able to inform the Authority well in advance of the exact date areas were to be handed over by the Contractor. Such information was important to the Authority for the effects on revenue from airport operations.

- d. The Financial Report did not show whether the total cost was likely to increase or decrease. It served as a record of committed expenditure resulting from decisions already taken.

In the report it was assumed, because of the C of C, that the contractual amount of £5,360 million was not going to be altered. In reality the contractual amount was provisional because all the quantities were remeasured as construction proceeded.

For this reason as well as the above mentioned limitations of the B of Q and the lack of a time schedule, the total cost could not be estimated. Thus the fact that the sum of £5,360 million was not going to be exceeded became apparent only at the beginning of the second year of the construction phase.

The SO and RE tackled these problems as they occurred:

- The SO tried to balance the financial implications of some of the Contractor's claims for delays to his programme because of reasons beyond his control by easing, with the Authority's approval, some of the contract conditions relating to the possession of working areas. For example, during phase 1 the SO allowed the Contractor to proceed with works in the restaurant area, phase 2, in order to balance delays caused by the User in the Snack Bar area. This way the eight week delay was reduced to a two weeks time extension.

- The RE tried to keep a balance between the SO's other instructions and the £0.124 million contingency. Thus the RE tried to have a say before working drawings were issued by the Architect to the Contractor, although in some cases the members of the Architect's design team tended to bypass the RE and agreed the quality standards of finishes directly with the Authority.

When the RE thought that they were going to overspend in an area, he always tried to balance the overspenditure by making savings elsewhere. For example remedial work of the tiling of the existing building had been included in the contract. When it became obvious that the cost was going to exceed the sum allocated in the B of Q, the RE persuaded the SO and Authority to omit the tiling of areas, where, in his opinion, it was not absolutely necessary, such as the baggage handling area.

6.3 Clients performance in decision making

It should be stressed that without the excellent performance of AD in reaching very difficult decisions quickly the performance of both the contractor and the project management team would have been severely impeded.

7. Potential Improvements to Project Control Suggested by the RE

The RE and QS indicated that the following would improve the control of such a project, without detracting from the credit which is due to the overall performance of all parties on the current project.

7.1 Management Organization

A. A Construction Manager should be appointed by the Client during the design and construction phases with duties defined in the C of C, to be closer to the Client, enjoy his confidentiality, and therefore assist the MT because:

- He would advise the Client as to the cost and time implications in relation to:
 - (i) design changes or improvements the Client or his departments have requested
 - (ii) commercial agreements with private operators (thus problems mentioned in 5.1b.I could have been avoided. See also subsection 7.1.e)
- He would provide better coordination between the Client and the SO, his site staff and the DT because the Client's wishes or the SO and his staff recommendations would be channelled through him.
- Decisions may be taken more quickly either because he will have been authorized to make them himself or because he will have quicker access to the appropriate decision maker.

B. The RE and QS should be involved with the project before tenders are invited for the main contract. This early appointment will allow them to have time to become familiar with the design details, identify problem areas, prepare a plan of the works and advise action or changes where possible in order to avoid future problems.

Ideally they should be appointed early enough so that they can participate in the preparation of B of Q, C of C and when the phasing of the works is decided by the DT, but this is not always possible.

C. It is preferable that the design is prepared near the site. A closer and less costly relationship can then be established between DT and the Client.

The DT members can then afford to obtain better knowledge of the actual site conditions, and services which is essential when complex phasing of the works is required, and thus the design is closer to reality, producing less variations to the contract.

D. When an existing building is to be extended, delays to the Contractor's programme can be avoided if prior to his appointment a contract is let direct to survey and divert gas and water mains, etc. in the area where the works will be carried out.

E. The RE believes that the interferences to the Contractor's programme outlined in sub-section 5.1bI could have been reduced, or even avoided, if the Users had been asked to carry out the installation of the ducts, installation networks and the architectural finishes within the leased areas using their own sub-contractors. The bank branch which was leased under these conditions was refurbished by the bank's sub-contractors without any interference to the Contractor's programme.

7.2 Cost estimating

The JCT C of C with quantities is not the right choice for complex projects because of the reasons mentioned in paragraph 5.3 c and d

make the accurate planning of the works, and thus the accurate estimation of costs, impossible.

A B of Q with approximate quantities can be used, but some Public Clients prefer the JCT with quantities because they think that more risks are carried by the Contractor and that they commit themselves to a known expenditure.

The cost estimate of a B of Q with approximate quantities and the final cost, provided that the amount of additional works is small, should not vary by more than 5%.

A carefully prepared B of Q requires that:

- together with the B of Q a document should be prepared outlining the schedule and stages of the works
- the items of the B of Q should be drafted in such a way so that they relate to work areas. Monitoring of costs then becomes easier and claims can be settled easier since the SO's instructions can be related to the relevant items.
- PC and Provisional items should be, where possible, more accurately defined. Sums included in the B of Q against these items can then be based on actual offers by nominated or prospective sub-contractors.

7.3 Planning and monitoring of costs and time

A. The interim and final certificates and the claims submitted by the Contractor or his sub-contractors should be measured and evaluated by the QS and RE before they are certified either by the SO or the RE.

B. A clause should be included in the C of C requiring the Contractor

to produce, and update regularly, a detailed construction programme, for the reasons mentioned in 6.2c.

C. Six weeks prior to the commencement of every phase, a site meeting should take place between the Construction Manager, if one has been appointed, the RE, the QS, the Contractor's Agent and Planner, and the sub-contractors likely to be involved during the phase.

The aim of the meeting will be:

- to list any information which was not available so far and agree on who will provide it and when
- to clear queries
- to plan works, and perhaps review the stage schedule
- to forecast any foreseeable variations.

The QS should then evaluate the forecasted VO's and then verify them with the party likely to be affected. The number and time required for the settlement of claims will therefore be reduced.

D. A micro computer available from the beginning of the contract period could help the RE to keep a record of the issued VO's. For the project approximately 750 instructions were issued with an average of four items per instruction.

Each item could have been registered with reference to the instruction under which it was issued. This record can prove helpful to the RE and Agent when, a few months after the issue of the instructions, they have to refer to them, especially in the evaluation of claims, otherwise it takes considerable time to locate the specific instruction.

7.4 Financial report

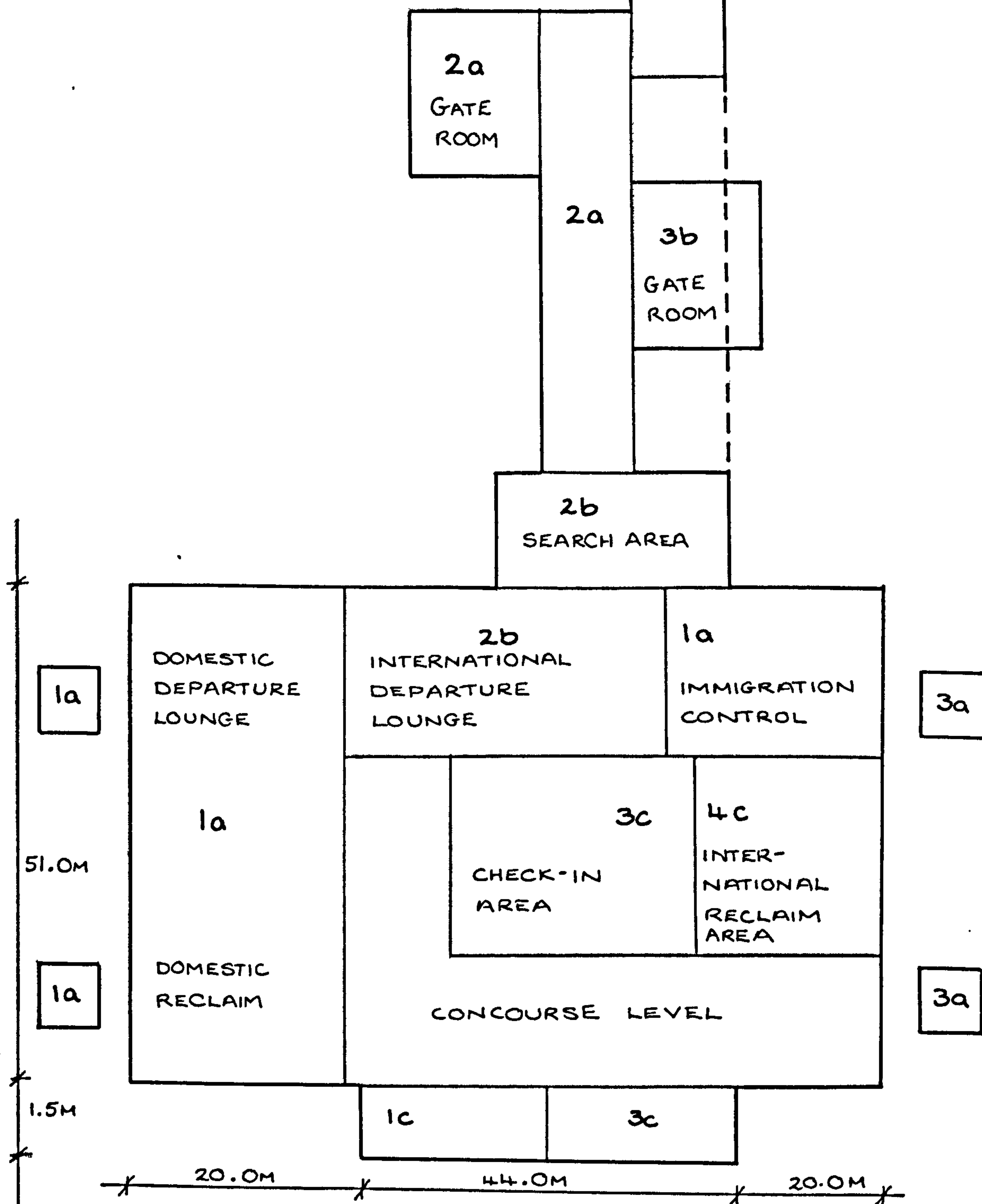
A financial report should be produced by the QS and RE every month or sufficiently frequently to indicate trends in time for remedial action to have some effect. A cover page inserted for the Client's information, should contain the information shown in appendix 7.

Tables should also be included in the report with detailed information on:

- The SO's other instructions.
- The SO's additional approvals.
- Variations of quantities.
- Adjustment and provision items in tender.
- Dayworks.
- Outstanding settled claims.

Appendix 8 shows the proposed lay-out of the first two tables proposed.

PLAN OF CONCOURSE LEVEL AND
PHASES OF CONSTRUCTION

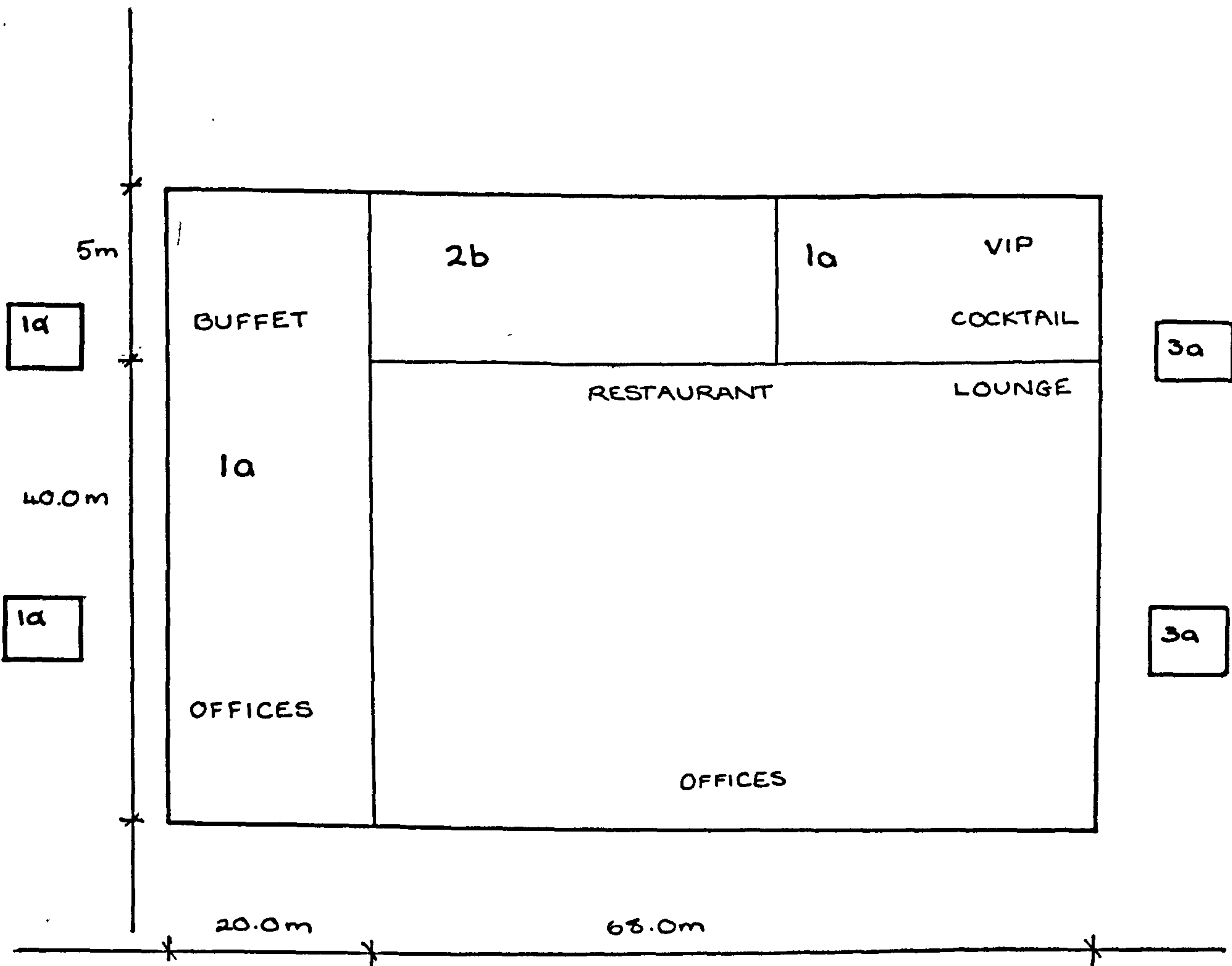


PHASES OF CONSTRUCTION

AREA

- 1a EXTENSION (NEW STRUCTURE)
- 2a EXTENSION (NEW STRUCTURE)
- 2b DEMOLITION OF EXISTING STRUCTURE, AND ERECTION OF NEW
- 3a NEW STRUCTURE
- 3b DEMOLITION OF EXISTING STRUCTURE, AND ERECTION OF NEW
- 3c RE-ARRANGEMENT OF INTERIOR

PLAN OF AMENITIES LEVEL



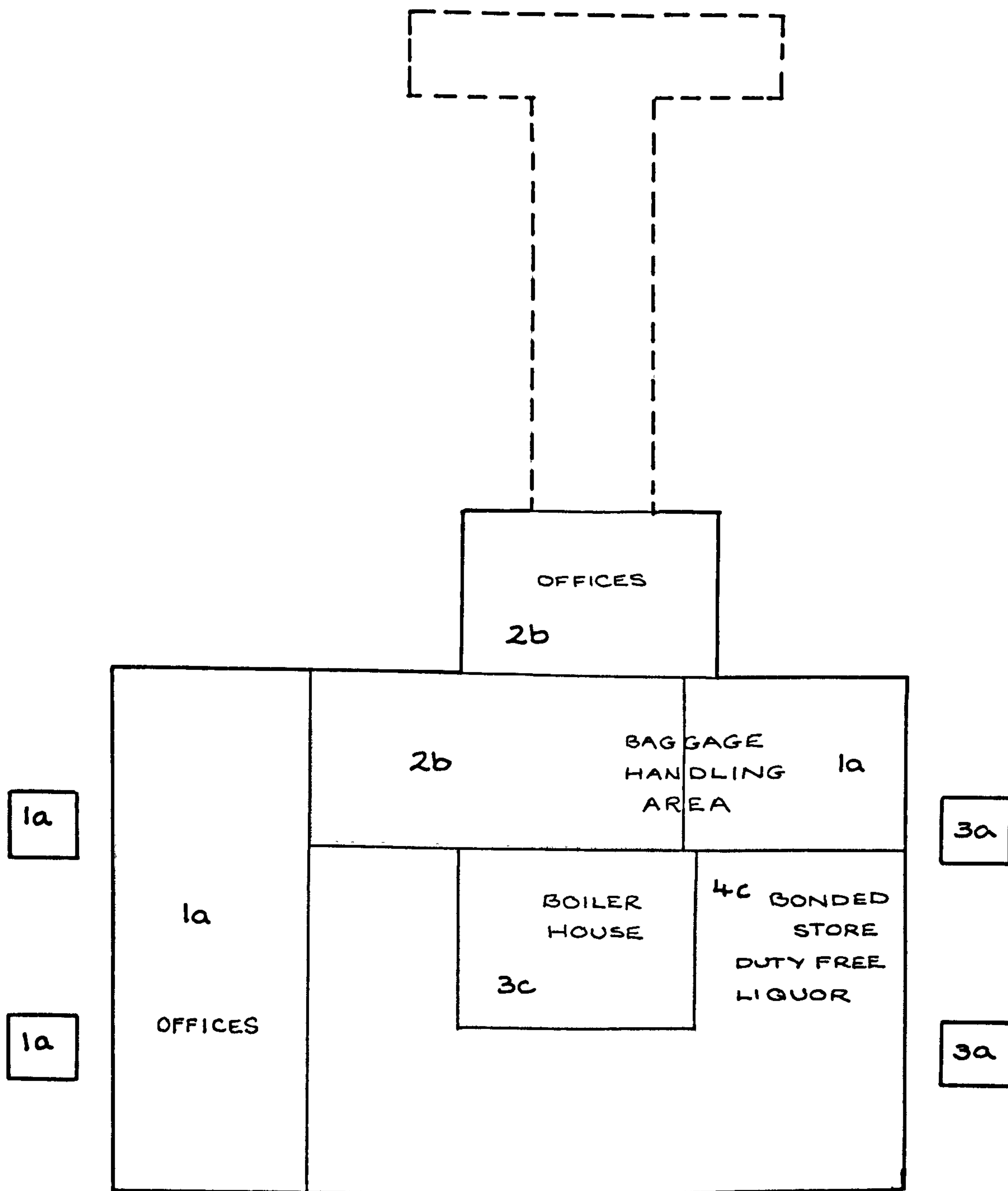
PHASES OF CONSTRUCTION

AREA

1a } AS IN PLAN 1
2b }

PLAN OF APRON LEVEL

APPENDIX 1
PLAN 3



PHASES OF CONSTRUCTION

AREA

1a
2b
3c
4c

AS IN PLAN 1

TABLE 1Analysis of final costs⁽¹⁾

		<u>In £ millions</u>
Contract amount		5.357 ⁽²⁾
Additional approvals		0.390 ⁽³⁾
Contingencies and daywork allowed for in tender	(0.124)	
<u>Required contingency</u>		
- Adjustment of PC sums	0.045 ⁽⁴⁾	
- Adjustment of Provisional items in tender	0.138 ⁽⁵⁾	
- Estimated effect of SO s other instructions	0.126	
- Contingency still required	0.021	
Net increase in contingency		0.206 ⁽⁶⁾
Amount of price/wage fluctuations		0.775
Outstanding claims		<u>0.110⁽⁷⁾</u>
Total		6.838

- Notes (1) Source of information, visit of the project on 2 December of Year 3.
- (2) Soon after the award of the contract, the contractor was informed by the SO that some of the works had been omitted at the Client s request. An Addendum B of Q was produced by the QS. The sum of £5.357m is the revised Contractor s offer.
- (3) Four months later the Client decided to approve the re-introduction of the omitted works. The Contractor agreed

to carry out the works at the tendered rates, adjusted to include the increases due to inflation. The remaining 50% of the sum is for additional works requested by the Authority in order to provide items which would improve the terminal s commercial returns or for improvements of architectural finishes.

- (4) The B of Q included 60 PC items of £3.112m total value ie 44% of the total contract amount.

The M & E services was one of those items. Its cost estimate was £2.240m in base prices.

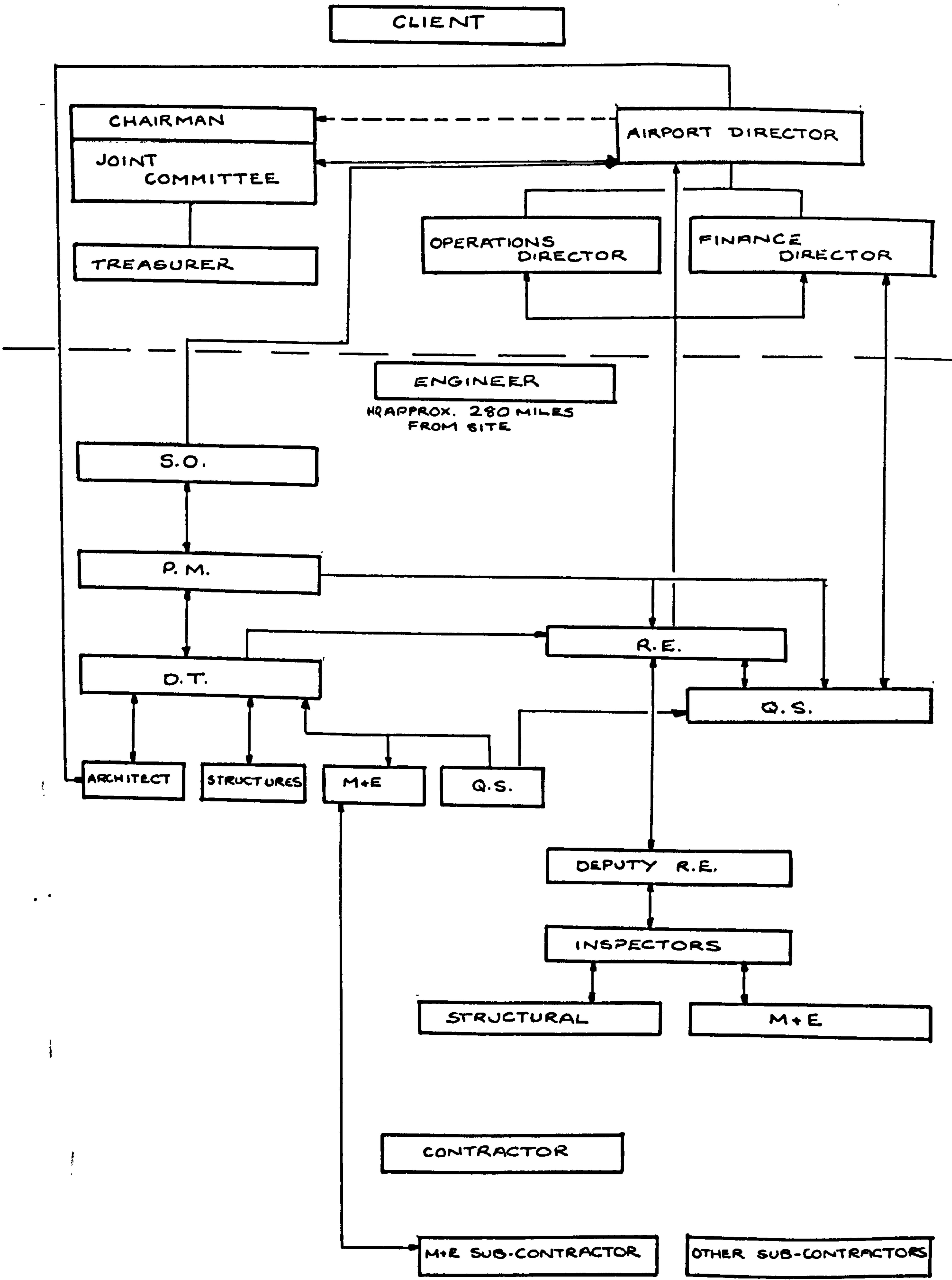
Other items for which PC sums were quoted were the supply and installation of conveyor belts, structural steel for staircases, suspended ceilings, window frames etc.

- (5) The sum of £0.465m was quoted in the B of Q for 114 provisional items. These items covered mainly preliminary and temporary works. Other items for which provisional sums were quoted were finishes not detailed in design, phones, rates, samples, etc.

- (6) Settled claims of £0.070m total value have been included in this sum.

- (7) Claims submitted by the Contractor but not settled until 2 December of Year 3. The Contractor had indicated that he intended to submit an additional, to the unsettled claims, number of claims.

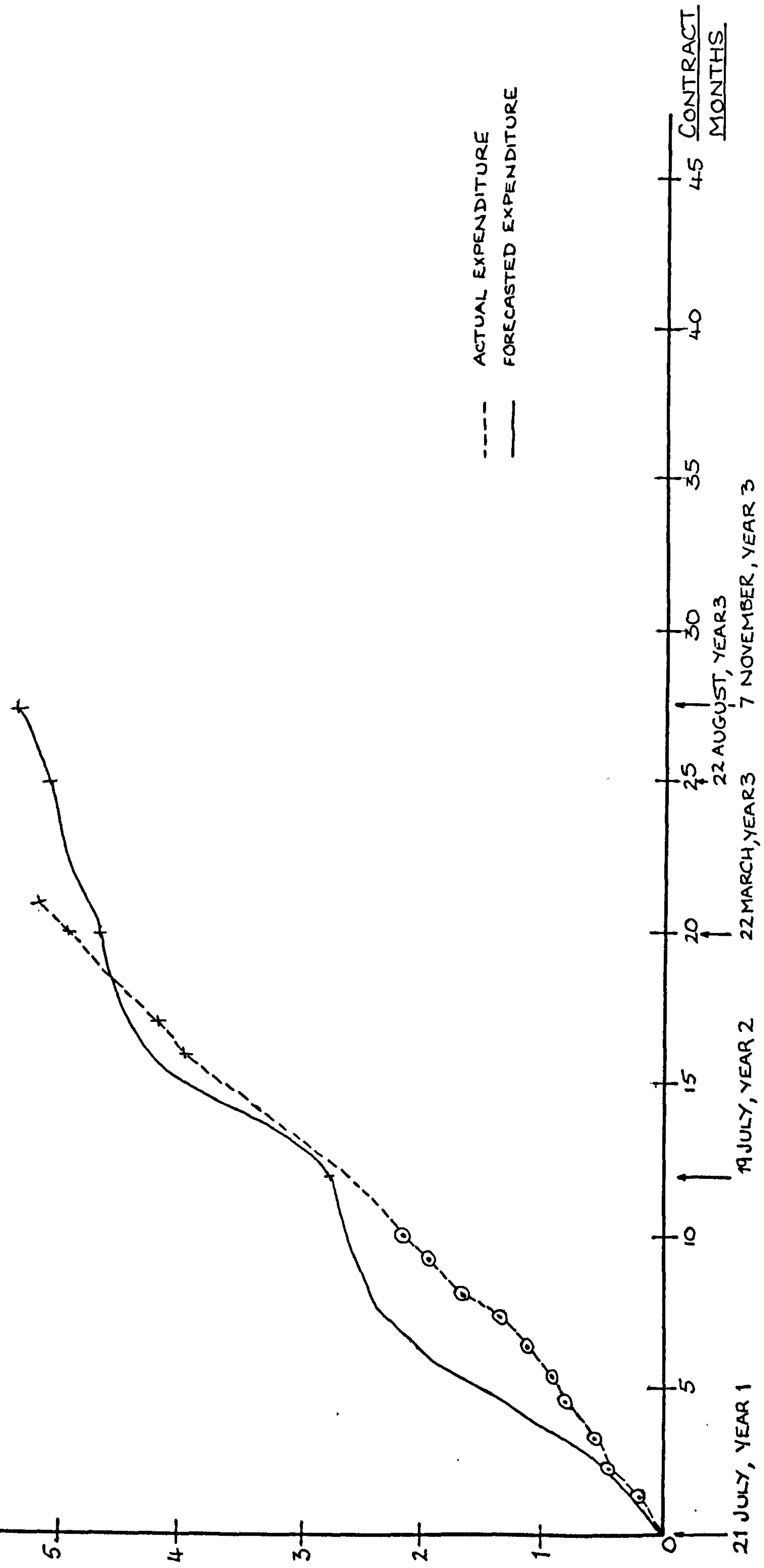
MANAGEMENT STRUCTURE



PROJECT COSTS
IN £M

APPENDIX 4

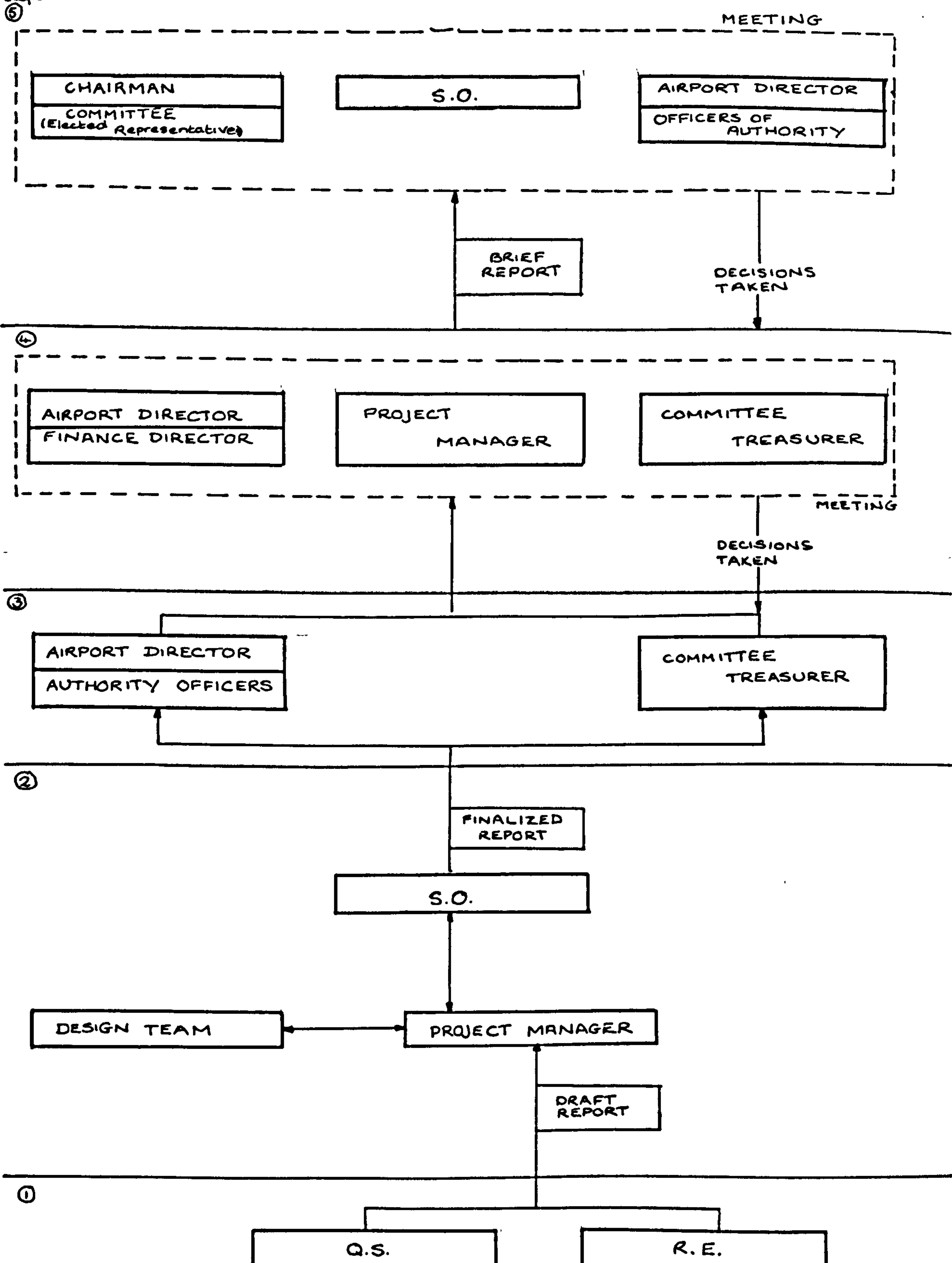
GRAPH SHOWING VALUE OF WORK
COMPLETED AGAINST PROGRAMME
VALUE



CIRCULATION OF FINANCIAL REPORT

(EVERY THREE MONTHS)

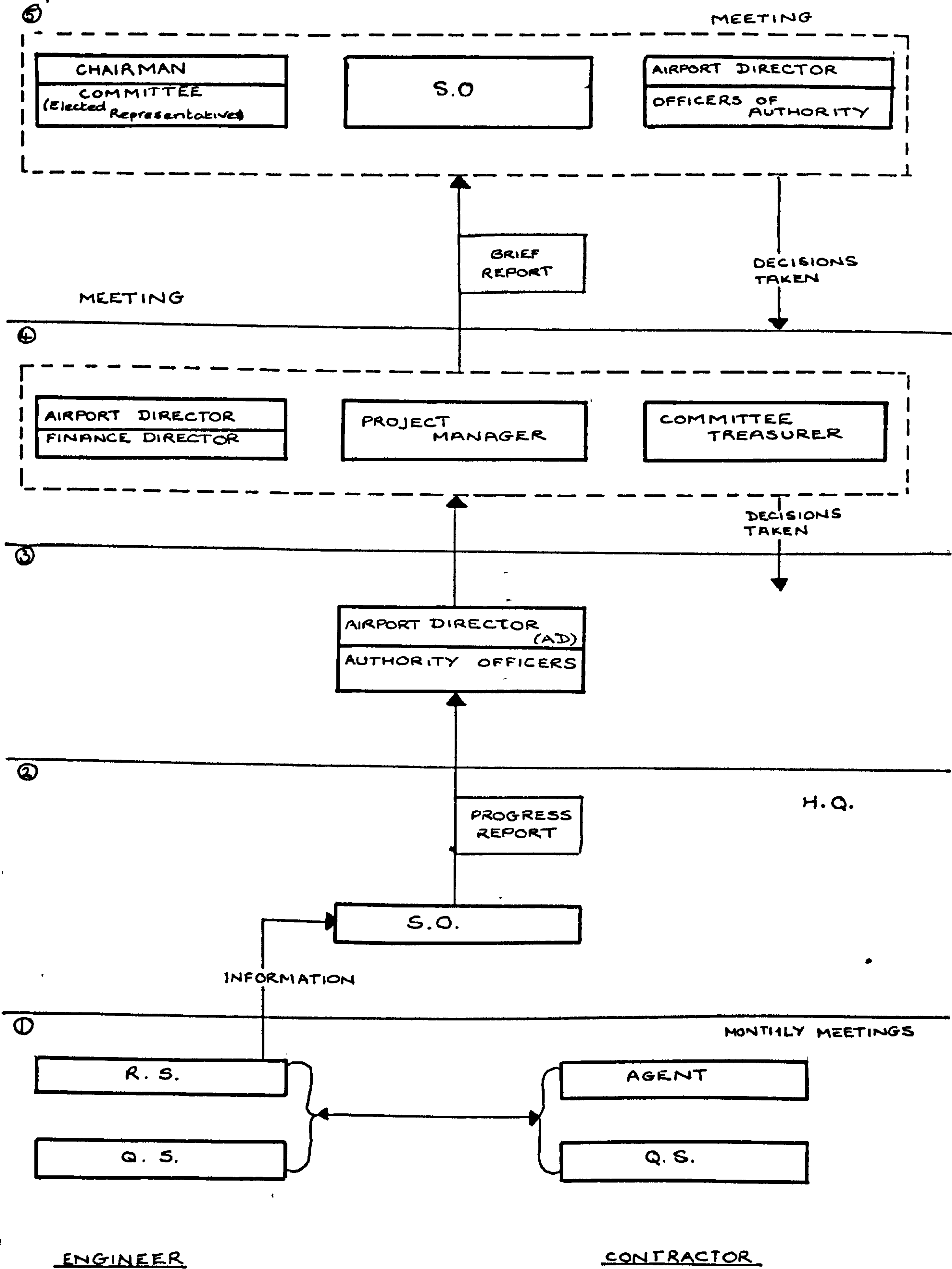
Steps



PROGRESS REPORT

(EVERY THREE MONTHS)

Steps



Monthly Report

Contents

1. Amount of money paid to date.
2. RE estimates of the next three interim certificates. (Note:
This would help the Client s Auditor to plan for future expenditure)
3. Original figure of contingencies in contract.
How much of this sum has been committed up to this month.
4. Percentage of works completed up to this month.
5. Estimate completion date.
6. Estimated value details of all instructions for more than say £200.
7. Claims submitted (sum).
8. Claims agreed (sum).
9. Updated cost estimate.

1. SO's OTHER INSTRUCTIONS

	BRIEF DESCRIPTION	COSTS					DATE OF ESTIMATE	FINAL BASIC COST	FINAL COST	DATE	REMARKS (REASONS ETC.)
		TENDER FIGURE	PROJECTED BASIC COST	PROJECTED INFLATION COST							
(1) (2)											

2. SO's ADDITIONAL APPROVALS

	BRIEF DESCRIPTION	COSTS					DATE OF ESTIMATION	FINAL BASIC COST	FINAL COST WITH INFLATION	DATE	REMARKS (REASONS ETC.)
		ESTIMATED BASIC COST	ESTIMATED INFLATED COST								
(1) (3)											

KEY:

- (1) NUMBER OF MEETING
- (2) BILL NUMBER
- (3) NUMBER OF INSTRUCTION

PROJECT D

The project was a concrete river highway bridge, built to replace an existing bridge which connected the conurbations on the South side of the river with the centre of a provincial town on the North side.

The Client of the project was the Highways Committee of the town's County Council who was the Owner.

CONTENTS

List of Abbreviations Used

1. Project
2. Owner/Client
3. Management Organization
4. Contract Control System
5. Causes of Delays and Cost Increases
6. Effectiveness of the Control System
7. Potential Improvement to Project Control, Suggested by the RE

ABBREVIATIONS USED

SPECIAL TO THIS REPORT

Owner	County Council of a town
BR	British Rail
Client	Highway's Committee of the town
Engineer	The Project Director of a firm of Engineering Consultants
ED	Client's Engineering Department
AD	Assistant Director of the ED responsible for the design, construction and maintenance of the County's highways
MT	Management Team
DT	Design Team
CC	Cost Controller
MC	Management Contractor
PC	Project Coordinator

STANDARD ABBREVIATIONS

RE	Resident Engineer
C of C	Conditions of Contract
B of Q	Bill of Quantities
CESMM	Civil Engineering Standard Method of Measurement
VO	Variation Order

PROGRAMME YEAR

Year (-1)	The Client deflated the costs to prices of November of this year.
Year 0	The project went out to tender in the Autumn of this year.
Year 1	Base prices refer to this date. (Nov. of year 0) i.e. the RE deflated prices in his report to prices of April of year 1. Award of contract and commencement of the works of phase 1 in April.
Year 2	Substructure of the main bridge was completed in August.
Year 3	Decks of the main bridge were jointed in November of this year.
Year 4	Phase 1 was completed at the end of February of this year. Phase 2 commenced immediately and was expected to be completed thirty weeks later.

1 Project

1.1 Purpose of the project

The Owner commissioned the first study for the replacement of the bridge almost ten years prior to the commencement of the construction.

Preliminary designs carried out during the first five years of the conceptual period were aimed at providing a bridge which would be a part of the urban motorway network which the Owner was planning.

Changes in the Owner's view resulted in the shifting of the emphasis from private to public transport.

A feasibility study commissioned by the Owner in the second half of the conceptual stage:

- showed that it would not be feasible to strengthen the existing bridge, especially because its dimensions would not be adequate to serve the growing traffic demands (public and private).
- derived the optimum dimensions of the new bridge, which was a bridge of a smaller width and capacity than those proposed in previous studies.

Corrosion measurements carried out approximately two and a half years before the commencement of the construction phase, showed that the decision for the replacement of the old bridge was urgent. Indeed, during the project's construction, the old bridge remained open only to light traffic; buses and heavy vehicles were diverted via other bridges.

A final design based on the proposals by the feasibility study was

commissioned a year before the commencement of the construction, and was completed before the project was tendered.

1.2 Technical description

The project consisted of:

- The bridge of an approximate total length of 674m and a width of 12.20m; four lanes of 3.05m each and a 2m footpath.
- The approach link roads on either side of the bridge.

The construction was carried out in two consecutive phases:

I. Phase 1 (description from South end to North)

- a. A road link into an existing roundabout.
- b. A 23m concrete bridge over a railway line. This consisted of precast beams in the deck and the abutments are founded directly onto clay. Underlying mine workings had been grouted prior to construction.
- c. A 80m length of road on an embankment.
- d. An approach span of 36m to the main bridge. The span was similar to the viaduct construction which is described below, and the abutment was founded directly onto clay.
- e. The main bridge had a central span of 160m width with two side spans of 100m each. It was a twin cell prestressed concrete box and was constructed by the balance cantilever method.

The two 36m high main piers N1 and S1 were founded on circular concrete caissons.

Gas and water mains were carried inside the box. Openings in the walls and floors of the box sections allow it to be ventilated and prevent concentrations of gas in the event of a damaged gas main.

Similar floor holes also allow water to drain out in the event of

a water main leak.

- f. A six span viaduct, each of 32m, supported on seven piers (N2 to N8). This viaduct was similar in construction to the main bridge and also carried the same gas and water mains as far as pier N4. The foundations were supported on piles either driven precast piles about 10m deep or bored in situ large concrete piles about 25m deep.
- g. A 22m concrete precast span bridge over a railway line.
- h. A two concrete precast span viaduct, each of 22m.
- i. A 20m concrete precast bridge over a street.
- j. Road works at the North end of the project consisting of a roundabout and the improvement of the existing road pattern.

II Phase 2

Which consisted of a 65m length of road linking into a roundabout on the South side of the bridge.

The reason this access road was built in the second phase was because it cut across the access to the South end of the old bridge which the Client expected to remain operational during the project's construction.

The project was designed by a firm of Consulting Engineers (the Engineer) apart from items a, b, c and j which were designed by the Client's Engineering Department.(ED).

The works were included in one contract which was awarded to a consortium of two Contractors in April of year 1.

1.3 Method of construction

1.3.1 Main bridge

The foundations of the piers of the main bridge was an area with high technical risks. The 1800t 11m diameter caissons were constructed in dry-dock and were towed into position over a ready prepared bed. They were then sunk through 11 to 12m of river mud clay and 4m into coal measures on to acceptable rock. It took five to six weeks to sink them and air pressures only had to go up to 196KN/m^2 which was less than the possible maximum of 245KN/m^2 .

One reason why the Engineer wanted caisson foundations was to allow exploratory drilling and grouting from the bottom into wall seams 5m and 20m below the rock head to ensure that no working voids existed or remained ungrouted below the foundation. After the caissons had been concreted and capped, the slender main piers, N1 and S1 were slip-formed. To prevent cracking they were shrouded in thermal blankets until the concrete temperatures had fallen to around 30°C above ambient.

With the pier heads cast, the Contractor erected prestressed concrete T-shaped brackets to support the first deck sections. The brackets were fixed to the side of each pier top to limit cantilever swing to just a few millimetres, instead of erecting supports from foundation level. This pierhead arrangement also protected the slender Freysinnet concrete hinge linking the pier with the deck.

Beside the caisson sinking these hinges were another risk area. Concrete was poured through a 9m long 90mm wide slot between the hinge points and achieved full compaction in a heavily reinforced void beneath. Two

trials of about 2m length were completed before the piers were attempted.

Balanced cantilever construction began after the initial 9m of deck over each pier had been concreted using fixed falsework. The Contractor, drawing on his past experience in this method of work, used simple trussed frame travelling forms jacked forward on rails.

The deck was extended in 3m pours with the rear end of the traveller frame temporarily anchored to the previous section with Dywidag bars. Moving forward was a two stage operation with rails repositioned first by jacking off a fixed traveller. The winches were then reversed and once the rails were secured to the deck, the traveller was pulled to its new location.

The units were concreted and stressed to a cycle of five working days with the 40N/mm^2 stressing strength aimed for in 48 hours. Thermocouples were inserted into each pour to help in determining likely strength of insitu concrete assisted with the need for concrete protection if stripping would induce unacceptable thermal shock during cold weather.

Concrete was skipped in by two tower cranes and was initially fed directly to the pour. As the cantilevers grew out of the reach of the cranes, additional skips were fixed to modify fork lift trucks which plyed between cranes and traveller.

Stressing involved twin USL 31 - strand tendons running to the corresponding unit on the balancing cantilver and as a result there were 60 tendon ducts in the upper flange at the pier head. The 275mm wide webs were also at their maximum 9.5m depths near the piers. The webs narrowed to 225mm wide further out from the pier. Grouting the ducts following within a day of stressing in order to avoid corrosion and any

strand relaxation problems. During cold weather various precautions had to be observed to enable concreting procedure. On occasions heaters were put inside the smaller depth boxes in order to keep cured concrete above freezing and allow grouting to proceed. Units on the shore side of the two main cantilevers were deeper and therefore heavier than the corresponding central span sections. As a result cantilevers spend most of their construction life out of balance and it was this vital to monitor loads at the pierhead pivot to prevent damage to the hinge.

1.3.2 Six span viaduct

At the tender stage the Engineer had proposed that six spans should be constructed using hanging formwork as for the main bridge.

After his appointment, the Contractor proposed that the cantilever principle remained the same, but instead of using formwork suspended from a framework above, a falsework cage was slid on steel beams spanning the piers beneath deck level. This method was possible because all the spans were accessible by cranes and of small span, which was not the case with the main bridge.

Three 1m deep beams run the full length of the span with their ends fixed to short I-beams running through each pier. As the cantilevers grew their rotation was restricted by temporary stub columns to the beams beneath.

This method of construction was economically attractive as compared to the method used in the main bridge because all the spans were nearly of the same length, and thus the beams could be reused with minimal alterations and also because the Contractor had sufficient beams of the

right length in stock.

1.3.3 North end access roads

The building of the North end access roads did not present any technical problems. The Client however expected the roads to remain open to traffic while the access roads were being built. Planning and coordination of the works by the Contractor, under the guidance of the Engineer's representative on the site (see sub-section 3.1) was therefore essential.

1.4 Construction programme

The contractual period for the construction of the two phases was for 147 and 30 weeks respectively.

The works of phase 1 commenced on the 28th April of year 1. A certificate of completion was issued by the Engineer for the 20th of February of year 4, i.e. on the date of completion stated in the C of C. Some small portions of the work (£0.100m) involved in stage 1 were extended for up to 10 weeks. The Contractor undertook the normal obligation to complete unfinished works during the maintenance period for stage 1.

The work on phase 2 commenced on the 21st February of year 4.

Critical activities to the construction programme of phase 1 were:

- the caissons
- the main piers S and N1
- the deck of the main pier
- the services and the surfacing of the bridge.

Briefly the dates of commencement and completion of the works of the main bridge, viaduct and South approaches and the North approaches were

as follows:

- The works on the main bridge started in April of year 1. The substructure was completed in August of year 2. The superstructure, cantilever construction, commenced in June of year 2 and was completed in November of year 3 when the two decks were joined.
- The black top, lighting, etc started in January of year 2 and were completed at the end of February of year 4.
- The works of the viaduct and South approaches started in April and the substructure was completed in October of year 2. The deck and some of the finishes were completed in February of year 4.
- The road approaches of phase 1 commenced in July of year 2 and were completed in February of year 4.

A more detailed account of the construction dates is contained in appendix 1.

Our observations started in the Spring of year 3 and were terminated in the Summer of the following year.

1.5 Costs

The Client in July of year 0 reserved the sum of £13.2 million, expressed in November of the previous year prices (year -1).

The sum of £9.4 million was for the construction of the project, the remaining £3.8 million for other items, such as site investigations land acquisitions etc. A more detailed analysis is shown in appendix 2.

The reserved sum was estimated on the data known to that date; the B of Q was produced a few months later, in October of year 0.

Appendix 2 also contains the Client's cash flow estimates in November year -1 prices and in outturn prices assuming a 10% annual inflation rate.

The Contractor's offer in April of year 1 prices, (base prices) for the construction of both phases was £10.7 million:

Phase 1	£10.4 million
Phase 2	£ 0.3 million

The following sums had been specified by the Engineer in the B of Q and were included in the £10.7 million.

- Provision sums (preboring of piles, connections of street leighting etc.)	.. .. ..	£0.120 million
- Prime cost sums	.. .. ..	£0.030 million
- Dayworks (for additional works to be carried out at daywork rates)	.. .. ..	£0.170 million

The total cost of phase 1, known in April of year 4 was:

		(in millions)
Cost in base prices	.. .. ..	£11.325
(This sum includes £90,000 of settled claims and £166,000 which was the estimated cost of phase 2)		
Claims paid on account in base prices	.. ..	£ 0.108
Price fluctuations		
(Assume 12% annual rate of inflation)	.. ..	<u>£ 2,565</u>
		TOTAL £14.001

Outstanding claims in base prices	£ 0.300
Price fluctuations of outstanding claims	<u>£ 0.100</u>
TOTAL £14.402	

The sum of £14.402 does not include an estimate of possible claims which the Contractor might submit in future.

Appendix 3 shows a more detailed analysis of the above sums and exhibit 1 illustrates the actual and predicted cash flows at the beginning of the construction.

2 Owner/Client

2.1 Client's nature

2.1.1 Client's characteristics

The Owner of the project was the Council of the County in which the town was situated.

The Council's Highway Committee, which consisted of elected councillors was named as the Client in the Contract with the Contractor. The Council's inhouse Engineering Department (ED) was the Client's representative during the design and construction of the project.

Appendix 4 shows the structure of the Client. The Director of Technical Services has no executive powers but his main role was to advise the Client particularly in relation to the political implications of the proposed project and be actively involved while projects were sent for approval to respective Ministries. In this capacity the Director was actively involved with the project while it was being examined by the Ministry of Transport.

The Executive Director of the Engineering Department had two Assistant Directors one for transport and one for highways. The highway's Assistant Director (AD) was responsible for design, construction and maintenance of the Owner's highways and bridges.

2.1.2 Sources of the project's finance

Every year the Owner requested the Central Government for "Authority to spend" against the Owner's budget. (The part of the budget relating to the maintenance design and construction of highways and bridges was based on the proposals of the AD and was examined by the Department of

Transport).

In his request together with the annual budget, the Owner included the following information.

- estimated cash flows in base and inflated prices of the new projects and
- the amount of money spent on ongoing projects in the previous year.

The Government could therefore decide whether the Owner should commit himself to new expenditure and check whether enough finance was allocated to the ongoing projects.

The approved budget was then financed by Government grants, the Owner's own income and loans.

The project was included in the application for "Authority to spend" in year 0.

The application was based on the conclusions of a feasibility study prepared by the Engineer, under the AD's supervision, three years earlier. The feasibility indicated the optimum width and the estimated annual expenditure. (In the application the annual expenditure was revised by the AD to November year -1 prices.)

Political pressure had to be applied by the Owner, (the Director of Technical Services became actively involved at this stage), on the Government to approve the project because the Owner had already committed himself to a high capital expenditure for other projects and had undertaken the obligation not to start new projects, for a few years.

The Government was persuaded to grant the "Authority to spend" because of:

- the annual cost of £0.5 million the Owner had to spend for the diversion of traffic to other bridges.
- the cost of delays because of the traffic conjection on the old bridge and the bridges the heavy traffic had been diverted to.
- closure of the existing bridge by year 4 would have been necessary.

Each year the Executive Director was allocated an annual budget of approximately £30.40 million, based on the "Authority to spend".

This money was allocated to specific projects each one of the two Assistant Directors had proposed six months prior to the beginning of the financial year. The greatest part of the £40 million was for projects managed by the AD.

There was no contingency sum included in the £40 million but the Client had a reserved unallocated sum.

In the case of annual overspending or underspending for any particular project, the AD had to apply, through the Executive Director, to the Client either to increase the annual budget of the project or to be allowed to divert the underspent money to another of his projects.

The prediction of the project's annual expenditure was therefore important to the AD.

2.2 Client's expectations objectives and attitude

2.2.1 Expectations

The Client's expectation was to build a project which would fulfil the purpose described in 1.1. Designing and building the project in the shortest possible period was therefore important because of the indirect cost to the Owner of the congestion problems to the other bridges and the direct costs due to the diversion of the buses.

The Client was also keen to adopt technical solutions which would provide a final product requiring low maintenance costs even if the implication of quality could result in an increase of the reserved budget.

2.2.2 Objectives

During the design and construction period the order in which the Client weighted the three interdependant variables was:

performance, time, cost.

Thus during the pre-tender, tender and construction periods the following choices were taken.

A. In the pre-tender (design) period

- The Client asked the Design Team (DT) to design the project in such a way so that the maintenance cost during its operation would be minimal, even at the expense of greater capital cost. For example deck waterproofing was being placed in double thickness. A layer of normal thickness Famflax polymer felt was topped by a layer of Famguard felt with an aluminium skin as protection from the heat of the hot rolled asphalt which was placed on top.

Stainless steel vent covers aluminium parapet rails and sockets on the piers for scaffolding to allow occasional inspection of the deck hinges where a fold-under access platform cannot reach are other examples of design solutions which would reduce the maintenance costs.

B. In the tender period

- The Contractors had to tender for a contract time schedule fixed by the DT i.e. tenderers were not invited to suggest an optimum between cost and time.

In the contract period however the DT had allowed for possible delays due to normal adverse (not exceptional) weather or other unforeseen reasons. Thus the contractor's risks were reduced, because he was allowed a less tight construction period, and he was therefore expected to submit a lower tender.

C. In the construction phase

- During the first year of the construction the Client's objectives were a good quality project, which would be finished within budget and within the contract time.

He was therefore prepared to accept a justified increase of the budget in base prices, i.e. up to 10%, and a few weeks time over-run, due to unexpected problems or further improvement of the quality.

- It was during the last year of the phase 1's construction that the Client, as a result of national economic pressures on his budget, became reluctant to approve further improvements which were likely to reduce future maintenance costs. For example the AD did not approve a suggestion by the Engineer for a bird screen, at an approximate cost of £0.050 million, which would be placed at the

pier heads, and would have saved the Client the maintenance cost of cleaning the concrete surface of the piers from the droppings of the birds. The AD suggested that the screen could be installed at a later stage if the problem became acute.

2.2.3 Client's attitude

The Client employed the Engineer at the beginning of the conceptual phase.

The Engineer under the guidance of the AD carried out the preliminary designs, feasibility studies and final detailed design described under the heading "Purpose of the project".

The final design was also prepared by the Engineer.

An independent firm of Consulting Engineers, employed by the Client at the Department of Transport's request, checked and approved the structural design.

During the construction phase the Engineer was responsible for the supervision and implementation of the final design.

The AD's decision and approval was required when changes to the design concept were required.

The Organization of the project's Management Team (MT) during the construction and the delegation of authority to its members is described under the heading of Management Organization which follows.

3 Management Organization

3.1 Management structure

Appendix 5 shows the lines of communication between the three parties involved i.e. the Client, Engineer and Contractor.

The Engineer had a Regional Office (Regional HQ) in the town where the project was located.

Appendix 6 shows the structure of the Engineer's HQ and Regional HQ. The upper half of the flow chart shows the upper management level in the Engineer's HQ. One of the 4 Regional Directors for the UK projects were the Director of the Regional HQ, Project Director shown in the lower half of the chart.

The Project Director was in direct communication with the AD and he carried out all the duties of the Engineer described in sub-section 3.3.

The Project Engineer was based in the Regional HQ and was in charge of the DT, which carried out the design.

A Senior member of the Engineer's staff was appointed as a Resident Engineer (RE) when the project was awarded.

The RE was permanently located on the site and was in charge of the site staff, shown in appendix 7, who were also members of the Engineer's staff. The RE was in communication with the Project Director, the Project Engineer and the AD.

With the Contractor's staff shown in appendix 8 the RE communicated with the Contractor's Project Manager, and the Construction Manager or his Agent.

As it can be seen in appendix 7 the Materials Engineer reported directly to the RE while the three Section Engineers, for the main bridge South and North approaches, and the Engineering Surveyor reported to the RE through the deputy RE. When the works involving the high technical risk elements were completed at the end of year 3, the Contractor started to reduce his site staff. For example the Construction Manager and the Chief Engineer (responsible for the design of the temporary works with the assistance of the Contractor's HQ) left the site at the beginning of year 4.

3.2 Types of contracts

The contract was in accordance with the ICE 5th Edition Conditions of Contract (June 1973 revised in January 1979).

The County Council was named as the Employer of the project.

The Consulting Engineering firm was named as the Engineer and the RE the Engineer's representative on the site in accordance with sub-section 2.2 of the C of C.

Before the tender of the Contract the design had been completed, down to the detailed drawings.

The B of Q was sent to the D of T SMM without provision for method related charges. The unit prices were filled in by the prospective

Contractors, and were related to quantities apart from some for major temporary works.

The Contract was tendered in two stages:

- In the pre-qualification stage, approximately 24 international Contractors who responded to the Client's announcement were asked to submit information relating to their experience with similar projects and the balanced cantilever method of construction, and their financial status. Six contractors and three reserves were selected, by the AD and the Engineer and were approved by the Client.
- The six chosen contractors were invited to submit their financial offers which varied between £10.7 million and £15 million.

The contract was awarded to the lowest tenderer in December of year 0.

The Contractor was a joint venture, formed especially for the project, of two subsidiary firms of an international holding firm.

Both the participating firms as members of the joint venture were responsible to the Engineer for the progress and quality of the works. One of the firms was in practice responsible for the construction of the foundations and the management of the labour force while the second firm was involved with the design of the temporary works for the superstructure, as well as the planning of the works.

The Contractor employed 20 domestic sub-contractors in addition to his own personnel and plant for specialized works. (The total cost of the sub-contractor's payments represented one third of the total final cost of the contract).

For certain parts of the contract concerning services such as gas, water mains and electricity cables, the Contractor had chosen his sub-contractors from a list of sub-contractors, prepared by the respective authority for safety reasons.

There were only two nominated sub-contractors, as these are defined in paragraph 59 of the C of C, but for minor works.

3.3. Delegation of authority to the members of the MT

The Engineer signed all the interim and final certificates of payment, the certificates of completion and granted extension of time of completion when it was required.

The RE's duty was to supervise the Contractor so that:

- his methods of construction and
- the quality of the finished works and their maintenance were carried out in accordance with the C of C and met the standards set in the final design.

The RE was in contact with the Project Engineer and would ask for his advice when he was faced with a decision concerning the design or when he was not clear about certain design information.

Additional detailed drawings, to those produced during the design period, were carried out by the RE's staff on the site.

When misunderstandings arose with the Contractor concerning the interpretation of the C of C or the design drawings and specifications, the RE was expected to give his independent opinion and advice to

the Engineer.

When circumstances, new data or Client's requests called for alterations to the final design, the RE tried to choose, or recommend to the Engineer, solutions which would satisfy the engineering safety standards, but would also improve the quality of the works.

Variation Orders (VO) were distinguished into two categories:

- Those which the RE estimated would result in a claim of less than £10,000 which he issued himself.
- Those for which he estimated the Contractor to claim more than £10,000, and were issued by the Engineer.
- Instructions which the RE felt that he had to issue to the Contractor in order to clarify various queries concerning specifications interpretation of drawings etc. and which had no financial consequences.

These instructions also formed a record and thus the Contractor could not later claim that he was delayed while awaiting for information from the RE.

The valuation of the VO's was carried out by the Engineer on the recommendation of the RE, some time after they had been issued. (If either the employer or the Contractor did not agree with the Engineer's decision, then they could appeal and go to arbitration, in accordance with article 66 of the C of C). In addition a considerable number were finally valued during the maintenance period. The dayworks were left by the Engineer at the RE's discretion.

The Deputy RE was responsible for the:

- measurements and coordination of measurements
- checking of price sheets of dayworks
- technical coordination of temporary works
- routine administration of the office

The Engineering Surveyor was responsible for land surveying and assisting in the financial Report described in sub-section 4.5.

The Section Engineers were responsible for the quality control and the initiation of instructions.

4 Contract Control System

4.1 Objectives of the system

The RE set up an information system which would supply information, to the members of the MT, related to the budget and programme in order to:

- a. Use the revised progress and cost data, to assist himself, or advise the Engineer, when decisions were made i.e. VO's had to be issued, claims were settled, the Client had to be informed as to the implications of design changes he had requested.
- b. Try to inform the Client of decisions made early enough, so questions would not be asked at a later stage i.e. when the implications of the decision became apparent and when it would be difficult to avoid the benefit of hindsight.
- c. Keep the AD informed of what was happening at the time it was happening so that he was in a position to answer any questions he was likely to be asked because of his accountability to the public (e.g. report and reply to questions asked by the Client, MP's local press etc.).

4.2 Programming and budgeting

4.2.1 Programming

Soon after his appointment the Contractor supplied the Engineer with a bar chart showing the duration of the work and the critical activities.

In the C of C it was stated that the Contractor had to produce a network. Both the RE and the Contractor's Project Manager agreed however that a bar chart would be more suitable for this type of linear project,

and because it was easier to use on the site. The RE tried unsuccessfully, to persuade the Contractor that an inclined line chart would be more appropriate in some areas for this type of project. Thus the RE produced such a diagram on his own. However the bar chart remained the only tool for medium and long term planning.

The bar chart was updated once manually since the beginning of the construction.

4.2.2 Budgeting

The RE, at the beginning of the construction, derived a payment cash flow curve, shown in exhibit 1. (thick line), in base prices.

For the prediction of the annual payments the RE relied on his past experience with projects of a similar nature in order to relate the quantity related unit prices of the B of Q to the Contractor's bar chart.

The actual payment curve in base prices is shown in the same exhibit with a broken line.

The RE was aware that the lagging of the actual payment curve, which occurred in the periods a and b, was due to slower rates of work than planned and not an indication that the total cost would be lower than the Contractors offer.

Almost a year after the commencement of the construction of phase 1 it became obvious to the RE that the total cost would be higher than the Contractors financial offer because of VO's issued and the measured

quantities. (The reasons for the slower rates of work and the increase of the total cost are analyzed in sub-section 5.)

4.3 Monitoring and control of the rates of progress of the costs

The rate of progress of the works was monitored by the section Engineers and their Inspectors (who kept daily diaries) and the RE's personal inspections.

Costs were monitored and controlled through the interim payments, and various regular meetings between the Engineer's and Contractor's site staff, shown in appendix 9.

A. Interim payments

The RE felt that it was important that the interim payments reflected as accurately as possible the percentage of the completed works because:

- they formed the input information on which he could predict the final cost.
- if the Contractor or one of his sub-contractor's defaulted and the works were stopped, the Client could have paid for more than had actually been built.

The interim measurements were the deputy RE's responsibility and were carried out by the Section Engineers independently from the Contractor.

The measurements were based on:

- assessment from tender quantities e.g. say 50% of the concrete had been poured.
- assessment from materials used, e.g. delivery of a quantity of concrete minus wastage.

- approximate measurements.

The accuracy of the interim payments was checked against the detailed final measurements which were usually carried out within three months after the works were completed.

B. Meetings between Engineer's and Contractor's site staff

The RE and this deputy RE held monthly site meetings with the Contractor's Project Manager, Construction Manager and Chief Engineer.

During those meetings there were no decisions made, but problems were discussed in relation to:

- Progress in settling claims
- Progress of measurements
- Rates for additional works
- Information outstanding between the Engineer and Contractor relating to the information and supervision of the job.

Ad hoc meetings were also held between the deputy RE and the QS of the Contractor, in order to discuss claims resulting from written VOs, to measure completed works and to fix rates. The deputy RE sent a weekly report to the Engineer relating to the monitoring of costs.

In addition to the above formal meetings, the members of the Engineer's and Contractors site staff were in daily contact.

C. Remedial works

The ordering of major remedial works, which could have upset the Contractor's programme and caused friction between the Engineer and

Contractor, was avoided because:

- Inspections were carried out by the Material Engineer and his Inspectors on and off site on materials before they were used in order to ensure that they complied with the design specifications.
- The RE and his Section Engineers ensured that workmanship was of a high standard, i.e. the works were structurally sound and finished according to the design standards.

4.4 Reporting and decision making

At the beginning of every month a Report was forwarded by the RE to the Engineer who then sent it to the AD as it is shown in appendix 9.

Sections relating to the report were produced by the Engineering Surveyor based on the information he received from the site, the Section Engineers and the deputy RE.

The updating of the Report was completed within three days at the end of each month.

The report was discussed during the monthly site meetings between the Engineer, Project Engineer, RE and the AD and his assistants.

The purpose of the meetings was to discuss the report which gave the Engineer a chance to inform the AD on decisions taken or possible solutions to various major problems and their implications of the cost and programme. The AD could then comment on them or require the examination of design changes requested by the Client.

4.5 Brief description of monthly report

The RE, based on his experience from other projects (mainly abroad) of

a similar size, nature and complexity, designed the monthly report with the intention:

- to be used as a source of information to the Client with regards to the progress and cost estimating of the project i.e. fulfil the objectives B and C outlined in sub-section 4.1
- help himself by using the report as a record of data when he had to make decisions which could have time or cost implications i.e. fulfil objective of sub-section 4.1.

The report was divided into two parts, more details of which are contained in Appendix 10.

- a. The purpose of the first part was to present a summary of the financial information (i.e. increases of the tender price, price fluctuations, settled and outstanding claims, payments to date and estimated total cost) and of the progress against the contractual programme.
- b. Details of the instructions, VO's claims, progress of the works were included in the 24 appendices of the second part.

The total cost estimates contained in the report were the RE's forecasts based on the VO's and measurements carried out so far as well as claims received. Predictions of VO's likely to be issued in future, or estimates of quantity variations or claims likely to be submitted by the Contractor were not included (or indeed attempted).

The Client was therefore aware that the estimated total cost (for example see appendix 3) was the lowest limit of the expenditure at the date the report was issued. The AD referred to appendices; 6A which showed the cost changes; 7 which contained the financial implications of the issued VO's; and 8 which listed the claims, their descriptions and their

cost implications, which had been submitted by the Contractor up to the date of the report's issue.

Appendix 6A also fulfilled the objective B of sub-section 4.1 because the Client had an opportunity to discuss those instructions he considered sensitive and request their omission. Thus for the remaining ones the Engineer assumed that he had the Client's approval at the time of issue.

The Engineer and the RE used appendices 1 to 10, 17 and 18 as references when they negotiated claims or before they issued instructions or VO's. Thus the report gave them a picture (subject to the limitations described in appendix 10 note 2 column 2) of the costs to date against the completed works and it was therefore a warning that they were going to exceed or underspend the budget. For example the RE used the information of appendix 1 as a record, especially for the evaluation of claims, for more information he referred to the weekly reports of the Deputy RE or to the daily progress reports.

5 Causes of Delays and Cost Increases

5.1 Substructure

In August of year 2, when the substructure was completed it was estimated by the RE that the cost of the substructure had increased by £0.125 million and the Contractor was entitled to a 3 week time extension of the contractual programme due to the changes 2b and 5 described below. A more detailed analysis of the cost increases appears in appendix 11. (Even though a time extension was not required).

The changes which caused the above increases can be summarized as follows:

1. Ground conditions differing from those envisaged at the time of tender.
 - a. Non homogeneous material at N2 requiring a change from precast piling to insitu piling (barrettes). Extensive site investigations were carried out which resulted in a 13 week delay to the completion of N2. The foundation design was also changed in S2 because of the results and for the same reasons as at N2.
 - b. The ground conditions at N3 to N7 (precast piles) required additional trials and investigations by the Engineer which delayed the completion of the North approaches by 2 weeks.
 - c. Unexpected buried foundations of buildings were found at N9 and N8 and the works were suspended by 1 week while they were removed.
 - d. Larger amounts of hard dig than had been estimated were encountered during the barrette construction which delayed the

works by 2 weeks.

- e. Boulders encountered at N11 leading to revision of the temporary works.
- f. Import of fill material due to unsuitability of excavated spoil at piers.

2. Changes in detail to suit revised technical or other requirements.

These included the following:

- a. Modifications requested by the Client to caisson reinforcement and main piers to reduce the possible effects of ship impacts. The method of construction - slipforming - was such that little delay occurred to the actual forming of the piers.
- b. Changes to welded mats to the main bridge Freyssinet Hinges to reduce bursting stress. The larger size mats had to be modified to suit drainage pipes stressing sleeves etc. and the pier construction of both structures was delayed by one week each (critical activity to the overall programme).
- c. Reduction in working time and excavation in compressed air for the reason explained in sub-section 5.3.1.c.

- 3. At the pretender stage British Rail (BR) considered it probable that no "possessions" would be required for the construction of N8 and N9 and the contract was let on this basis. On closer examination BR stated that it was necessary to erect the scaffolding during possessions. This revision on N9 was made after working methods had been agreed and the work started. This delayed the completion of

N9 by four weeks. Before the construction of N8 started the BR's revised requirements were incorporated into the method of working before the works were started and thus the effects were minimized.

4. Changes in quantities revealed by ad-measurement.
5. Industrial action, on a national level, by the crane drivers during the sinking of the caisson which delayed the main bridge construction by 2 weeks (critical activity).
Other non critical activities such as the piers of the North approaches were also delayed.
6. The interaction of the above items causing extensive re-programming and disruption to items mainly involved with work other than on the main bridge.

5.2 Problems encountered during the erection of the superstructure

I Difficulty in translating drawings

A. Newcastle approaches viaduct

The boxes which make up the span have a variable cross section. The DT produced detailed drawings for three typical boxes. When the construction of the span commenced it was realised that:

- a. the working drawings were not suitable for the labour force which was using them.
- b. mistakes were likely to occur as the details of the remaining boxes were derived from the typical sections.

The RE, the Engineer and the DT discussed the problem, and it was decided that the Engineer's site staff would have to produce detailed

drawings for each box. For speed of production and ease of commencement a drawing was produced for each box.

The construction of the viaduct span was delayed for four weeks, until a uniform flow of design information between the RE and Contractor was established. This delay however did not have an effect on the overall programme because the activity was not critical.

B. Main bridge span

The detailed drawings of the main bridge's span had been produced in the same way as for the viaduct. The experience with the viaduct however helped the RE to identify the problem before the date the construction of the main bridge span was due to commence.

Detailed drawings for every box were produced and thus the commencement of the construction of the span which was a critical activity was not delayed.

II Problems because of construction methods

Problems during the anchorage of the boxes were encountered in two cases:

- a. In the viaduct. When the Contractor tried to accelerate the process of anchorage of the boxes, the anchorage burst. It was found that the burst happened because the concrete strength was too low.
- b. In the main bridge the anchorage also burst because of a wrong additive in the cement. This problem resulted in the change of sampling methods. (Until this happened, samples were taken from every other batch delivered).

III Temporary Works

The Engineer reluctantly accepted the proposed by the Contractor, temporary works for the joining of the two cantilever parts of the middle span of the main bridge. During the joining, cracks appeared on the surface of the span, because of wrong loading.

The Engineer immediately requested the Contractor to alter his temporary works. As a result a claim has been submitted by the Contractor but the Engineer has rejected it because, "the Engineer's approval does not release the Contractor of his responsibility for the temporary works."

IV Minor Problems Because of Design Detailing

- a. Minor problems with the precast slabs occurred. At the Contractor's initiation some changes in their design were introduced.
- b. Reinforcement details of some sections had to be clarified, because the proposed reinforcement in the working drawings proved impractical.

5.3 Financial and time extension claims

Claims arose because of the following reasons:

1. External effects outside the control of the Contractor:
 - a. Adverse weather. The Contractor could only claim for an extension of time if, during the construction of a critical activity he encountered exceptionally adverse weather.

In cases where the Contractor claimed an extension of the contract

period due to inclement weather, as a result of which the works stopped or productivity fell, the RE had to decide whether the Contractor could have forecasted it and thus had allowed for it in his tender offer.

The Contractor did not submit such a claim.

- b. National strikes. The Contractor requested in year 1 a time extension because of the crane drivers' strike. (He did not claim financial compensation).

The RE and the Engineer felt that the claim was justified, but they reserved the right to grant the extension in the last few months of the construction of phase 1 if it was necessary. Under the circumstances the extension was not required because the delay was covered by the time allowed for delays in the contractual period. (See sub-section 2.2.2b).

In the case of strikes of the Contractor's labour force or of the labour force of one of his suppliers, the Contractor was not entitled to financial compensation or time extension e.g. The Contractor's claim for an extension of time "due to delays arising from failure to obtain a dock, to build the caissons, due to Union objections to the Contractor working inside the dock yard" was not admitted by the Engineer.

- c. Changes of scope of the design which were either initiated by the Client or by the Engineer due to unforeseen technical problems or details which were overlooked by the DT at the design stage. e.g. The Contractor claimed £0.138 million because the original proposed method of excavation described in sub-section 5.1.1.d would have resulted in a large number of hours of chiselling time. It was claimed that this was reduced by the use of additional equipment such as a pre-boring rig.

The principle of the claim was accepted by the Engineer but the extent of the work included under the chiselling item was not agreed (The Engineer approved a £0.045 million payment on account). Another such example is the Contractor's claim that extra stressing temporary to the hinge of the main bridge could not have been foreseen at the tender stage. The Engineer rejected it because in his opinion it was required to limit rotation to specified limits.

2. Interpretation of C of C. e.g. The Contractor claimed £0.025 because the reduction in the quantities for compressed air excavation in the caisson was due to the method of working which was at his risk. The Engineer rejected this claim because under the C of C it was an admeasurement item and because it was referred to in the pre-tender discussion between the Engineer and the Contractor.

Such claims also arose after the issuing of V0's because of 5.1.1.c reasons. For example the Contractor claimed £0.052 million because of variations to drilling and grouting, Freysinnet hinge thermal protection to the main pier and solid pier. The Engineer agreed to £0.022 million but he disputed the Contractor's claim for 2 weeks' overheads for the whole site.

3. Fixing of rates (ICE sub-section 5.2.2)

The Claims which had been submitted by the Contractor up to April of year 4, were due to "external effects" and "interpretation of the C of C". For a number of these claims the Contractor had not submitted detailed accounts or even indications of the sums he was claiming for, although some of those claims were for works completed almost two years prior to April of year 4.

The RE expected more claims to be submitted towards the end of the project, because of all three reasons analyzed above; even for works completed in the early stages of phase 1.

6 Effectiveness of the Control System

6.1 Supervision cost

The total cost of supervision, excluding the Client's overheads, was approximately £0.450 million i.e. below the originally estimated budget amount mentioned in appendix 2 which had been reserved by the Client.

6.2 Benefits from the control systems

The RE was of the opinion that the management of the project's construction was successful because the Client's objectives had been fulfilled:

- a. Quality. The design specifications had been observed and thus the end product will require minimum maintenance.
- b. Time. The project was opened to traffic within the Contract's time schedule.
- c. Cost. The estimated total cost, in base prices, (in April of year 4) was going to be within the budget which had been reserved by the Client, and approximately £0.7 million higher than the Contractor's tender offer.

The Control system's contribution was that:

- the objectives b and c of sub-section 4.1 had been fulfilled.
- the report was used by the Engineer and RE as a record of the actions, and their estimated implications, which had already been taken. Thus when a decision had to be taken, or questions were asked by the ED's personnel etc. answers could be found quickly without having to look for the required data through piles of paperwork.

The RE indicated a number of limitations, which in his opinion are not unique to this project, and which have an affect on the effectiveness of control systems:

1. The cost estimate and cash flow curve, exhibit 1, were unreliable (when compared to the actual costs as works progressed) as indicators of under or overspending.

Their inaccuracies were due to:

- a. the cost implications of the VO's ordered during the construction phase and which could not have been forecasted at this stage.
- b. changes in the rate of progress or the sequence of the works.
- c. the B of Q which contained a number of quantity approximations, errors, duplications etc., mainly due to the short time within which it was produced and the lack of detailed drawings.

The experience of the RE and Engineer were therefore very important when comparisons of actual and estimated costs were being interpreted.

2. Difficulty in the updating of the total cost estimates and the forecasts of annual expenditures. (annual budget forecasts had to be altered during the financial year); because:

- a. The implications of the VO's were not:
 - always estimated before they were issued
 - evaluated and settled within a reasonable time after they had been issued, as it was mentioned in appendix to note 2.

In the RE's opinion it was not always possible to know the implications of a VO at the time it was issued, but he believed that the evaluation and settlement of VO's should be carried out sooner

than it was actually done.

- b. Claims were taking a long time to be submitted justified and settled as it was mentioned in sub-section 5.3.

Indeed, based on his experience with other projects, the RE expected a number of claims to be submitted during the maintenance period i.e. long after the works for which the claims were submitted had been completed. The Engineer, if such claims were properly substantiated, would be inclined to accept them although he could reject them according to the C of C (Clause 54.4 a and b).

The RE was of the opinion that:

- the number of late claims depended on the Contractor's expected profit, to the actual profit made.
- Contractor's purposely delay the provision of detailed particulars for submitted claims, although in some cases the delay is justified because the indirect implications become apparent long after the works have been completed, for later when facts are forgotten and thus the Contractor feels that he is in a stronger negotiating position.

Records, similar to those contained in the report, can therefore prove useful to the RE and Engineer when they negotiate such claims.

- 3. The fluctuation of the numbers of the Engineer's site staff and the amount of detailed drawings which had to be prepared (see 5.2.2.d) reduced the amount of time that the RE had available for examining the future works.

In the event this did not appear to cause any major problems and is probably a reflection of the thorough preparation of detail in the Engineer's original design. This examination of future problems is required by the supervision team in order to head off problems by:

- a. Looking at available information for future works e.g. drawings, construction methods etc. and deciding whether existing data was sufficient.
- b. Preparing any addition information the Contractor may need when he starts work in these areas.

7 Potential Improvement to Project Control, Suggested by the RE

The RE made the following comments, and suggestions for improvement which in his opinion are applicable to any project of a similar size, nature and complexity as project D.

7.1 Management organization

1. The RE feels that in public projects the Client expects the Engineer to:

- manage the construction of the project
- recommend and, if agreed, implement solutions (and when possible produce an evaluation of their implication), to the Client's requests of changes.
- report to the Client on time and costs as works progress.

In this project although there was no contingency money allocated to the project, other than a small percentage of the tender price for provisional sums and dayworks, the Engineer issued VO's and then reported to the AD. For major changes such as the modification of the pile foundations mentioned in sub-section 5.1 the AD was informed of the decision before the VO was issued. This view, about the Client's involvement in public projects, was also endorsed by the AD.

The RE would have welcomed more of the Client's detailed involvement in the decision making during the construction phases for example this could have involved the presence of a member of the Client's staff based on site on a full time basis as a project co-ordinator (PC). This would have been feasible in this instance where the Client has a considerable degree of technical expertise. The PC's primary objective would have been to ensure that the working period solutions provided reasonable value for money.

The RE staff will tend probably towards solutions which are technical improvements but the Client may feel that he is not prepared to expend addition money for a marginal improvement.

2. In relation to the Engineer's site staff.

a. Site personnel was being moved to and from other projects in order to meet the Engineers commitments in other sites. Some problems occurred until the newcomers familiarized themselves with the project, the people they worked with and the RE's expectations from them. Thus the personnel movements had an adverse affect on the site team's performance and cohesion but was offset by the continuity and the considerable experience of the RE. The RE believed that Clients should exercise control in the movements of the Engineer's personnel. The PC mentioned above could probably undertake this function.

b. Among his site personnel the RE would welcome the appointment of a Cost Controller (CC) i.e. a senior Engineer with a knowledge of and a bias towards, the control of costs.

Some of the CC's duties would be the following:

- After the appointment of the RE and the CC on the site, one of the first acts would be to check the B of Q in order to make corrections of usual inaccuracies contained in the B of Q's mentioned in sub-section 6.
- The CC would measure and agree individual items with the Contractor when RE's instructions were issued.
- The CC would be involved, together with the section Engineer, with their evaluation before VO's intended for the improvement of quality were issued. (The RE identified two types of VO's, those issued in order to improve quality, and VO's issued in

order to tackle technical problems).

- The CC would prepare the monthly report actively and not mechanically.

3. The RE's authority, deriving from his technical knowledge and seniority within the Engineer's firm, was important in order for him to be independent in his advice to the Engineer when problems from the interpretation of the C of C, design specifications, or inadequate design information arose:
 - a. For example when it became apparent to the Contractor's and Engineer's site staff that there were difficulties in the translation of drawings, explained in sub-section 5.2.2.1, the RE's authority was important when he argued the case (to the Engineer) for more detailed drawings.
 - b. A period of a few months elapsed from the time the RE and the Contractor's site staff were appointed until their relationship i.e. communications consultations etc. became less formal, although at all stages instructions were confirmed in writing.

The RE believed that during this period it was very important for him to establish his authority over the Contractor's site management. Thus during the first few months when problems arose, irrespective of their cost implications, the RE was prepared to argue for differences of principles and in some cases refer the matter to the Engineer. To emphasize the extent of this (RE's control) the other actions in the direction in establishing authority are for clear administration system and fair and prompt on account decision with regard to period.

7.2 Forecasting, monitoring and control of total cost and annual expenditure

The RE outlined the limitations in the accurate forecasting, monitoring and control of total cost and cash flow in base prices, as stated in 6.2.1 and 6.2.2.

Besides the appointment of the CC the RE suggested the following actions which in his opinion would improve the accuracy and effectiveness of the cost forecasting monitoring and control.

a. VO's could be evaluated easier and claims settled earlier if:

- the Contractors together with the priced B of Q were asked to submit a sealed envelope which would contain the make-up of the quoted unit prices. Only the selected Contractor's envelope would be opened and the remaining would be returned. The analyzed unit prices would help the Engineer to estimate the cost implications of VO's more accurately and the settlement of claims simpler.

In the RE's opinion a number of Contractors would welcome such an arrangement.

- clause 52 (4)d of the ICE C of C was modified so that the Contractor was obliged to submit a detailed account of the direct costs within a few weeks after the submission of his claim for a VO. This would not restrict the Contractor from claiming for indirect costs when they became apparent at a later stage.

b. In the RE's view it would be ineffective as a method of controlling costs for the Client to expect the Engineer to commit himself with an accurate cost prediction of the implications of a VO before it was issued.

As an example he recalled his experience while he was employed as an RE for a number of contracts of a multi-million multi-contract project.

The Client expected the Engineer to state the exact amount of cost increase or saving in his request to the Client for "authority to spend" before he issued a VO.

A number of VO's were issued and authority to spend was obtained later, after the full cost implications had become apparent and agreed between the Engineer and the Contractor. i.e. the Client became aware of the expenditure he was committed to, when he awarded the "authority to spend", either because the Engineer felt that it was impossible for him to make an accurate cost prediction before he issued the VO or because the VO was urgently required if the works were not to stop until the authority was obtained.

- c. The RE believed that the use of a micro-computer for the storing of information relating to instructions which had been issued would have proved quite useful because of the speed he could recall such information when needed.
- d. It would have been preferable if dayworks and provisional sums were registered in the report on a separate table and their expenditure was monitored independently from the expenditure of other costs.

7.3 Type of contract

Because of the project's nature of works (i.e. the number of specialized sub-contractors whose works represented almost one third of the contract's value, the Northern and Southern viaducts which would have been tendered as separate contracts, etc.) the choice of a Management Contract could have been feasible.

In the RE's opinion the advantages or disadvantages of such a choice, as opposed to the chosen type of contract, would have been the following:

- The Engineer could have benefitted by the Management Contractor's

(MC) experience in methods of construction.

- The MT, with the MC's participation, could have been more effective in the planning and heading off, of future problems during the construction phase, although this objective could have been fulfilled by the RE and his personnel if more people were employed.
- Due to the long relationship between the Client and the Engineer mentioned in sub-section 1.1, when the Client decided to build the project the detailed design was completed in a very short period. It is therefore doubtful whether there was room to overlap the design and construction and thus finish the project earlier. (It should be noted that the construction of the main bridge which was the critical activity would have to be tendered as one contract).
- There was the danger that Contractors with the required technical knowledge and financial soundness would not have tendered for small packages.
- The RE believes that in the construction of bridges once the concept has been agreed and the optimum dimensions have been worked out following a feasibility study, changes likely to be requested by the Client, as it was the case with this project, have small cost or time effects on the project's budget or time schedule and can be accommodated by a conventional type of contract.

Thus the advantage of flexibility which in theory is a feature of the Management Contracts, would have been of small significance for this project, since it is virtually a single discipline project.

Dates of Construction1 Main Bridge

- Caissons.

The construction of the caissons commenced in April of year 1. The caissons were sunk into position at the end of February of year 2.

(The duration of sinking was 2 weeks, per caisson).

- Pier N1.

The erection of the pier commenced in January of year 2 and the pier was completed in July of year 2.

- Pier S1.

The construction commenced in February of year 2 and the pier head was completed in August of year 1.

- Decks.

The construction of the North deck commenced in July of year 1 and was completed in August of year 3.

The construction of the South deck commenced in September of year 2 and was completed in November of year 3. The close of the two decks was completed in August of year 3.

The black top and other finishes of the decks commenced in January of year 3 and were completed in February of year 4. (Apart from those mentioned in sub-section 1.4.

2 Viaduct

- Demolition and excavation for N2 to North abutment.

Works started in April of year 1 and were completed in February of the following year.

- Piles and Pile cap.

The piling was carried out in parallel with the demolition and excavation.

It was completed in April of year 2.

- Piers and backfill.

The works started in August of year 1 and were completed in October of the following year.

- Deck of viaduct.

Works started in December of year 1 and were completed at the end of January of year 4.

- Black top and finishes.

They commenced in Year 3 and were completed in February of year 4.

1.4.3 South approaches

- Pier S2.

Commenced in March of year 2 and they were finished at the end of the following year.

- South abutment.

Works commenced in June of year 2 and were completed in March of year 3.

- Deck of South approaches.

Commenced in September of year 2 and were completed in March of year 3.

- The railway bridge.

Commenced in October of year 2 and were completed in April of the following year.

1.4.3 Roadworks

The approaches roadworks started in July of year 2 were completed at the end of February of year 4.

1 Analysis of the finance reserved by the Client £13.2 million.

	(in millions)	(in millions)
Bridge structure	£7.497	
Approach roads	£1.366	
Work on behalf of statutory undertakers (e.g. gas, water etc.).. .. .	£0.617	
Cost of construction		£9.480
Demolition of old bridge		£1.700
Design		£0.540
Supervision		£0.480
Site investigations, land acquisition, advanced works		<u>£1.00</u>
TOTAL		£13.200

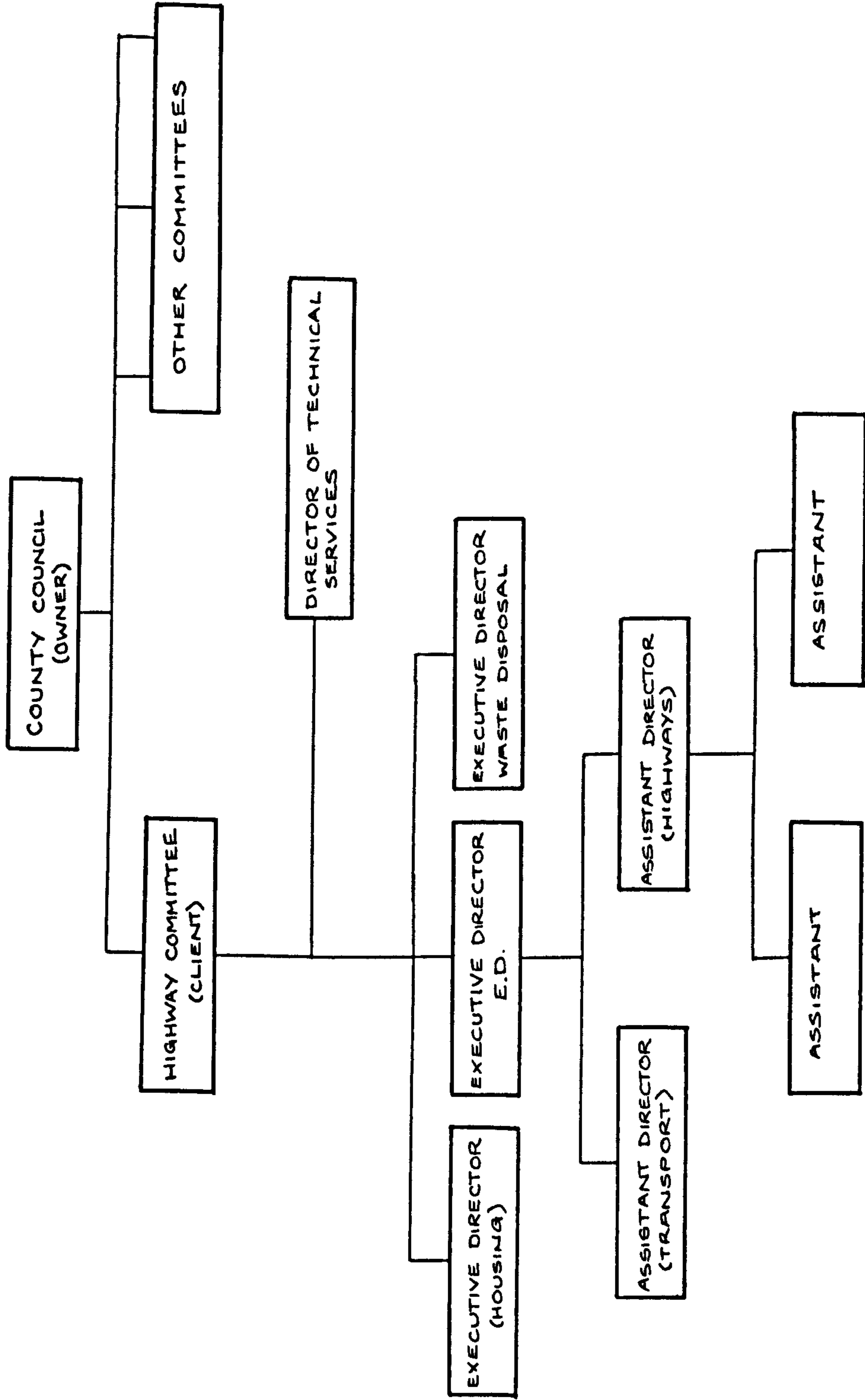
2 Expenditure in year (-1) prices and in outturn prices

	(in millions) Year (-1)	(in millions) Outturn
Years (1)/0	£0.283	£0.283
Years 0 / 1	£0.203	£0.223
Years 1 / 2	£4.617	£5.586
Years 2 / 3	£3.041	£4.047
Years 3 / 4	£2.042	£2.989
Years 4 / 5	£2.528	£4.071
Years 5 / 6	£0.427	£0.756
Years 6 / 7	<u>£0.047</u>	<u>£0.091</u>
TOTAL	£13.200	£18.050

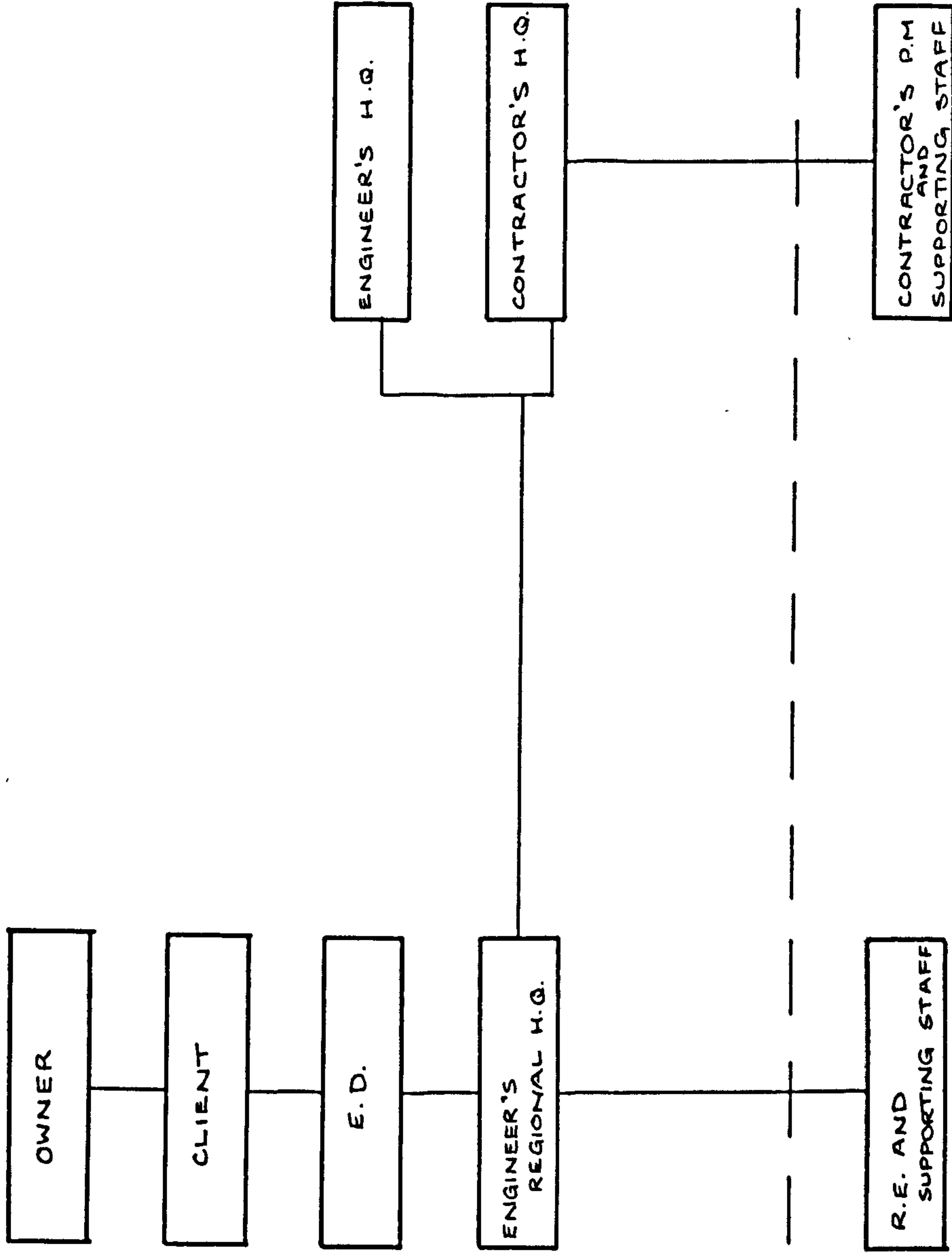
Estimates of costs in April of year 4

(in millions)

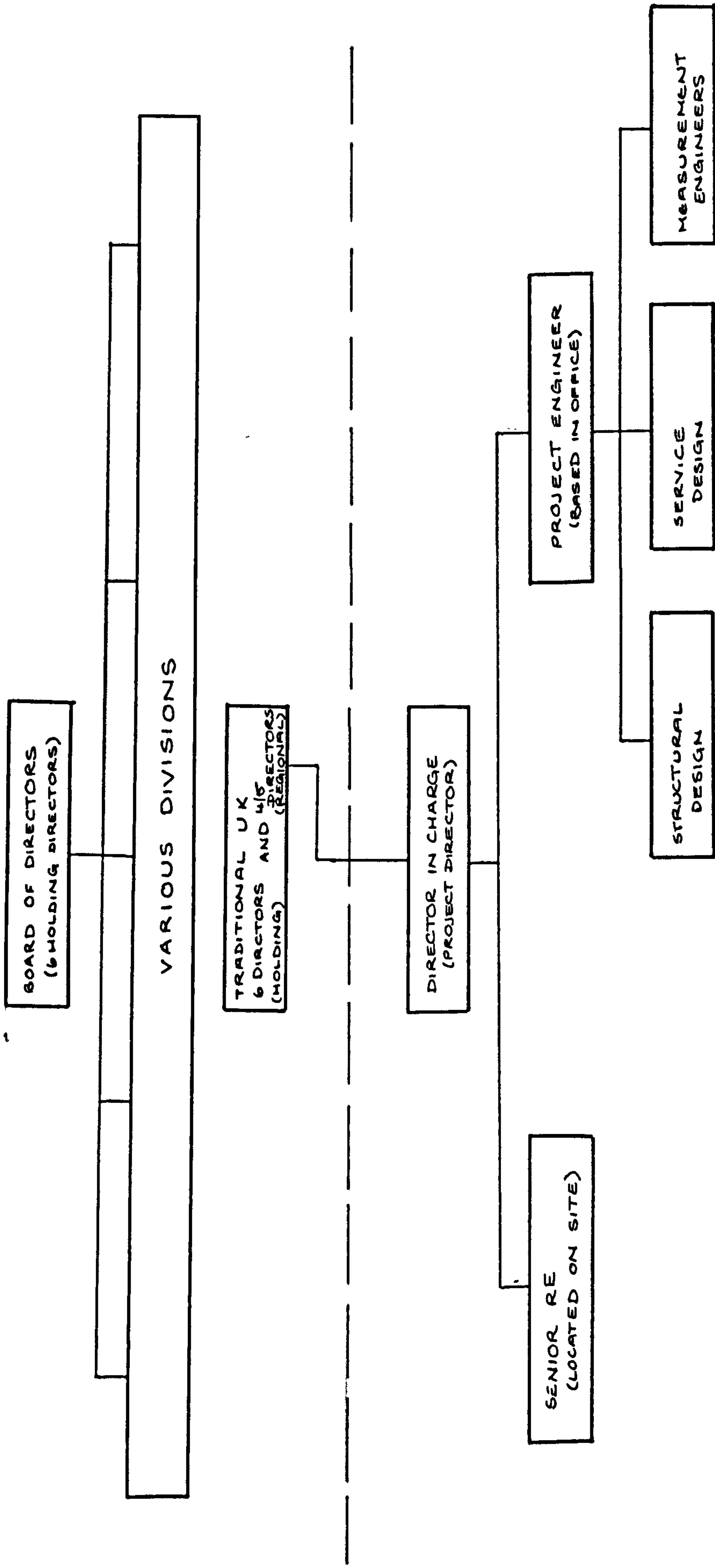
1.	Preliminaries	..	..	..	..	..	..	£1.795
2.	Roadworks	..	..	..	..	..	..	£1.035
3.	Main bridge	..	..	..	..	..	..	£4.074
4.	North approaches	..	..	..	..	..	..	£2.801
5.	South approaches	..	..	..	..	..	..	£0.936
6.	Street lighting	..	..	..	..	..	..	£0.087
7.	Statutory undertakings	..	..	..	..	..	..	£0.231
8.	Provisional and dayworks	..	..	..	..	..	..	£0.200
9.	Phase 2	..	..	..	..	..	..	<u>£0.166</u>
10.	Tender in basic prices	..	..	..	..	..	..	£11.325
11.	Claims (basic cost)	..	..	..	..	..	..	<u>£0.108</u>
12.	Estimated total in base prices	..	..	..	..	..	..	£11.436
13.	Price fluctuations (12%) average	..	..	..	..	..	..	<u>£2.565</u>
14.	Estimated total cost	..	..	..	..	..	..	£14.001
15.	Outstanding claims in base prices	..	..	..	..	..	..	£0.300
16.	Price fluctuation of outstanding claims	..	..	..	..	..	..	£0.100
17.	Gross total	..	..	..	..	..	..	£14.402



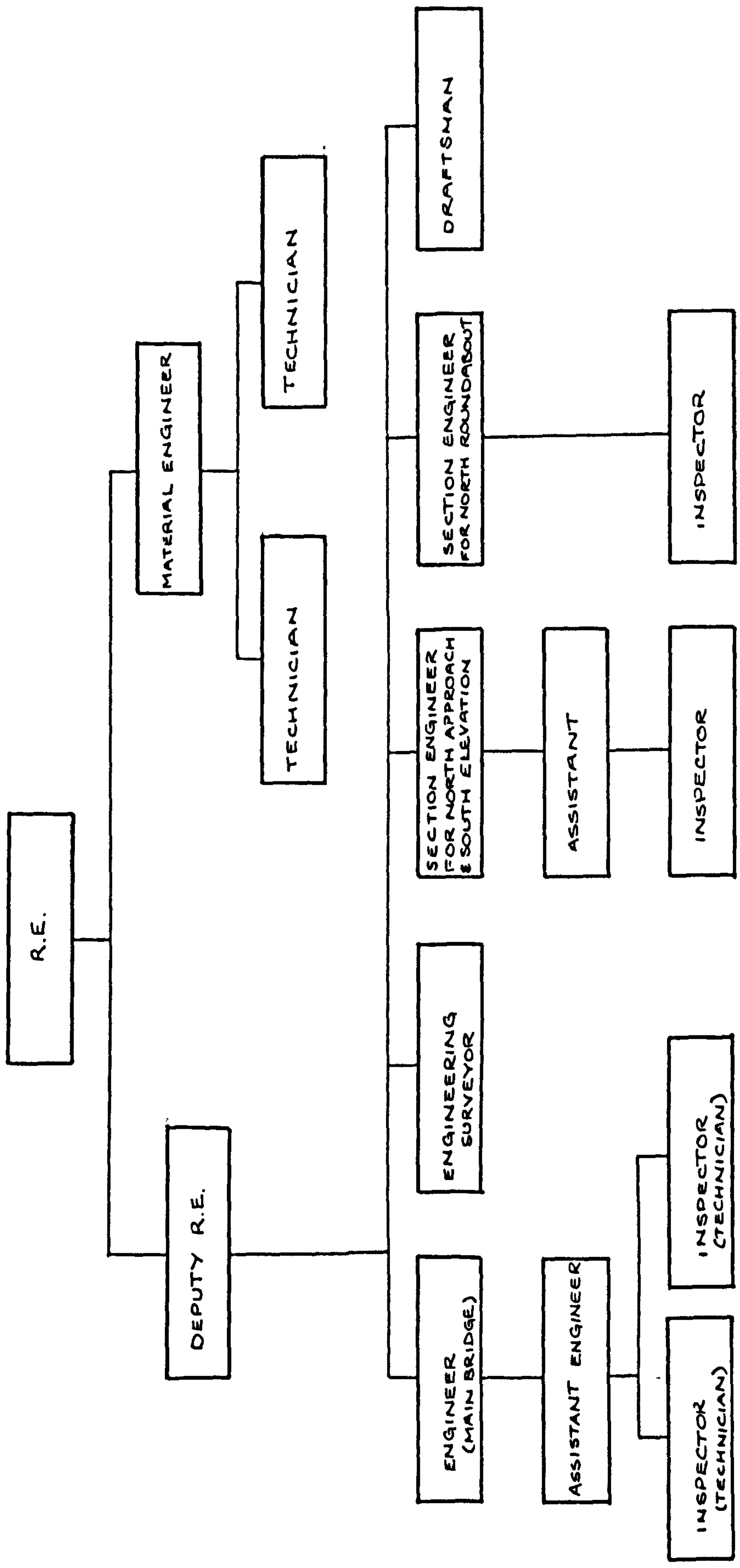
CONTRACTUAL RELATIONSHIPS



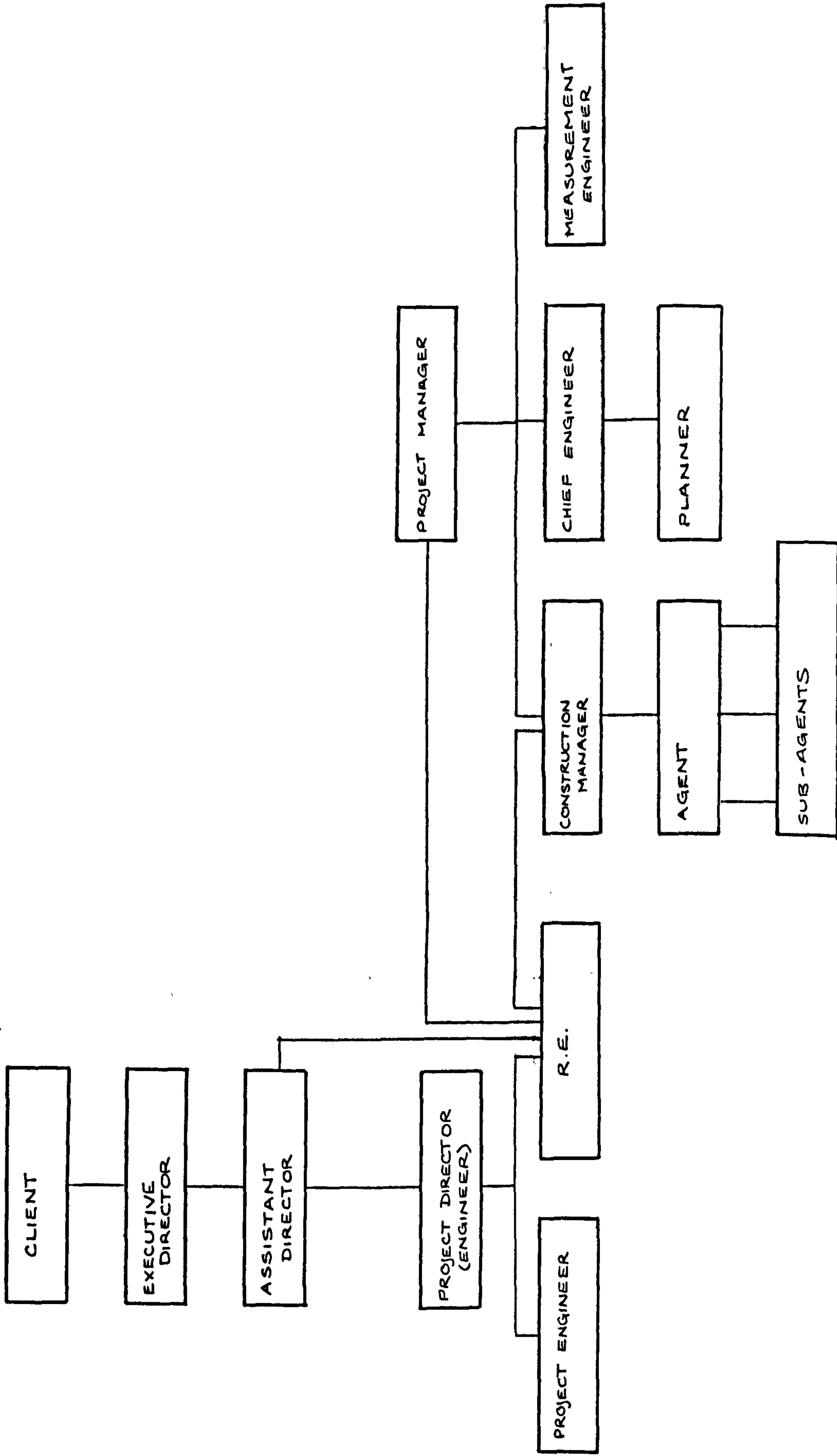
ORGANISATION OF THE ENGINEER

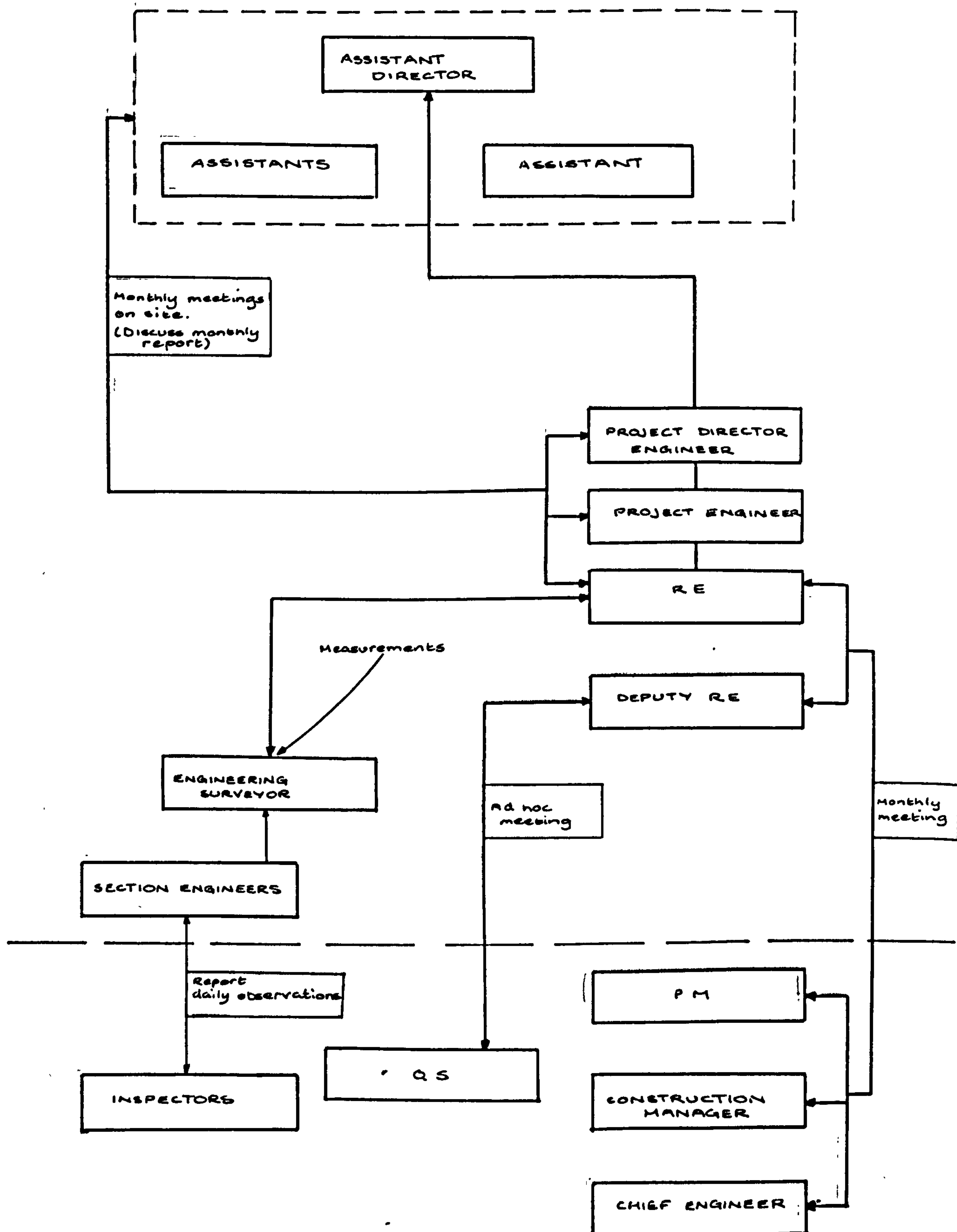


ENGINEER'S SITE ORGANISATION



LINES OF COMMUNICATIONS BETWEEN MEMBERS OF THREE PARTIES





- 20. (C) Summary of third party claims
- 21. (C) Report on outstanding third party claims
- 22. (T) Week numbers

Notes

1. T Time control C Cost control Q Quality control

2 - Appendix 2

This appendix was only of limited use in decision making, but it gave a general picture of the progress to date.

- Appendix 4

This showed the fluctuation of the Contractor's workforce. Every week the PC submitted a report on the workforce he had employed on the site to the RE. (It was a term of the C of C).

- Appendix 5

This appendix was a summary table consisting of seven columns. A copy of the table contained in the report of February of year 4 is shown as exhibit 3.

Column 1 of the table contained the tender sums of the nine groups of Bill contained in the B of Q. (The B of Q was divided into 20 items Bill in accordance with CESSM).

Column 2 listed the cost variation of each one of the nine groups due to changes of measured quantities the evaluation of those issued instructions which the Engineer had evaluated so far and the settled claims.

The data contained in this column were not updated very frequently, because the instructions issued or the changes of quantities were not evaluated at regular intervals and most of the submitted claims were expected to be settled after the completion of phase 2.

In April of year 4 the Engineer was asked by the Client to carry out an evaluation of all the VO's issued to date.

Column 3 was the sum of 1 and 2 and showed the total sum as it stood at the date of issuing of the report. (Subject to the above mentioned limitations).

Column 4 showed the estimated cost of each group and their total sum to the end of the construction period. It also contained the estimated cost of claims submitted and accepted in principle by the Engineer, the estimate of price fluctuations, the estimated cost of outstanding claims (in basic prices and inflated prices) and finally the gross total, which was the sum of the above and represented the estimated total cost of the project (in each month).

Column 5 showed the payments made during the month the report was issued and column 6 the cumulative payments for each group since the beginning of the construction.

Column 7 showed the increase or decreases of each group (at base-date prices) as compared to the tender sum. The sum of this column which also included the estimate of the submitted claims showed the so far estimated diversion from the original offer and can be a warning to the reader (e.g. RE, Client, Engineer etc.) that over expenditure or under

expenditure was likely to occur.

The appendices which followed could be used to show why this deviation from the original estimate was likely to occur.

- Appendix 6A

Contained a summary of the cost changes for each group of Bills, also fulfils the objective b of cost control, (stated in sub-section 4.1) because at the time of the reports' being issued, the Client can discuss those instructions he considers sensitive, and can ask for some of them to be omitted. Thus for the remaining ones, the Engineer assumed that the Client approved them before they were issued.

- Appendix 6B

Contained the variation orders and quantity changes which were valued during the month the report was issued.

The purpose of appendices 6A and 6B is to provide a fuller explanation of the change, and the reasons for it.

- Appendix 7

Contained variation orders issued by the Engineer in accordance with clause 52 of the C of C.

- Appendix 15A

Was for internal use (by the Engineer's staff).

- Appendix 18

Was useful for the final accounts.

- Appendix 20 .

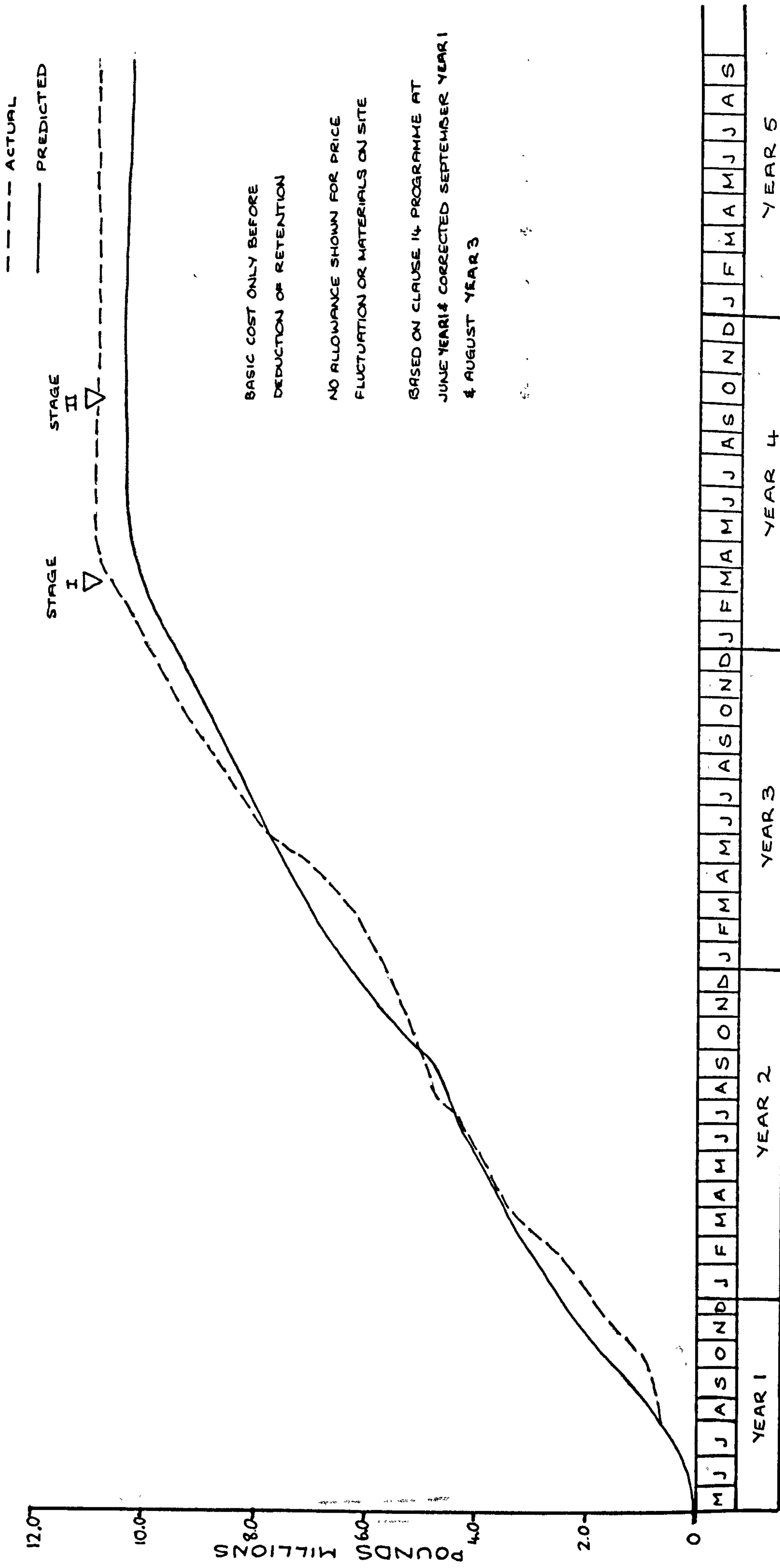
These claims are paid by the PC. The Client however wanted a record of them so that he could exert pressure on the PC not to delay his payments.

SUMMARY OF FINAL ESTIMATED COST AUGUST,
SUB-STRUCTURE TO MAIN BRIDGE AND APPROACHES

BILL	TENDER £	FINAL ESTIMATED COST £	COMMENT
Main Bridge Special Foundations	513,045.09	458,530.54	Reduced Quantity of compressed air working
'1 Main Bridge Special Foundations	901,030.49	1,052,761.76	Including 150,000 on a/c for barrette construction and 6,000 on a/c for Herkules - Claim No.3,
'2 Main Bridge Caps & Piers	514,544.43	548,911.98	
'1 North Approach Special Foundations	223,330.96	137,830.29	Reduced length of precast piles. Includes on a/c payment of £9,000 for Herkules piling.
'2 North Approach Caps & Piers	381,449.22	370,171.04	
'1 Railway Special Foundations Viaduct	236,401.83	265,543.61	Including £45,000 on a/c for barrettes.
'2 Railway Viaduct Caps & Piers	450,271.08	460,370.83	Earthworks only measured. Remainder as Bill of Quantity (Tender)
Provisional Sum		15,513.51	Allowance of £120,000 for pre-boring is included in Bill D/1, E/1 and F/1. The final cost is for site investigations
Dayworks	53,645.00	70,347.96	Tender allowance adjusted to allow for price fluctuation over period up to August, of Year 2
Claims		19,640.00	Disruption to N.A.V. only (Claim No.5)
Total	3,273,718.10	3,399,621.43	This represents an increase of £125,903.78 or some 4% of this part of the works.

EXHIBIT I

COMPARISON OF ACTUAL COST WITH PREDICTED COST



CONTRACT DURATION

CONTRACT DETAILS

<u>Employer</u> :	<u>Engineer</u> :
<u>Contract</u> :	<u>Contractor</u> :

CONSTRUCTION TIME

COMPLETE

Start Date	Monday 28th April Year 1	Monday 21st Feb. Year 4
Original	I-147 Weeks-20/2/83	II- 30 Weeks-11/9/83
Revised	I (See Below) *	II

PROGRESS

	STAGE 1	STAGE 2	TOTAL
Time Allowed-Weeks	147	80	177
Time Elapsed-Weeks	147 (100%)	6 (20%)	153
Tender Cost (TC) £M	10.4	0.2 (+0.1)	10.7
Forecast (% of TC)	10.4 (100%)	0.1 (1%)	10.5 (97%)
Final Cost (FC) £M	11.1	0.2 (+0.1)	11.4
Cost Expended (% of FC)	11.0 (99%)	0.1 (1%)	11.1 (97%)

FINANCIAL SUMMARY

Tender Sum	£10,729,000	Previous month
Final Estimated Cost	£11,436,000	£11,436,000
Estimated Price Fluctuation	£ 2,566,000	£ 2,571,000
Estimated Total Outturn	£14,002,000	£14,008,000
Claims Submitted	£ 409,000	£ 409,000
Amount in Final Est. Cost	£ 109,000	£ 109,000
Amount Outstanding	£ 300,000	£ 300,000

WEATHER

	1 Weeks - Stage II
Inclement Weather: 4½ days in March	24 Weeks (Total to Date)
Weather this month has been	

CONTRACTOR'S WORK FORCE

Staff 18 No.	Others 31 No.	Sub-contractors 64 No.	Total 113 No.
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OVERALL PROGRESS

Good progress has been maintained on installation of pedestrian guardrail and this is now virtually complete.

Progress on roadworks has been somewhat slow but the contractor is now increasing the resources in order to obtain an acceptable rate of construction.

- * (Section C - Handrailing to Bridge - 3.4.83)
(
(Sections A & B - Part of the North Approach Roads - 24.4.83)

	1	2	3	4	5	6	7
	Tender Sum £	Variation Order 1 - 6 £	Authorized Sum (1 & 2) £	Estimated Sum £	Monthly Payment £	Total Payment to £	Total Change from Tender (4 - 1) £
1 Preliminaries (A)	1,862,851	- 3,620	1,859,231	1,795,824	10,136	1,643,634	- 67,027
2 (B,C)	954,000	Nil	954,438	1,035,527	90,701	853,827	+ 81,089
3 Main Bridge (D)	3,663,087	+ 3,276	3,666,313	4,074,146	41,428	4,052,993	+ 411,109
4 Northern Approaches (E,F,G,K)	2,606,503	+ 17,989	2,624,492	2,801,031	82,786	2,956,300	+ 194,528
5 Southern Approaches (H,J,L)	897,925	Nil	897,925	936,006	(1,930)	900,110	+ 38,081
6 Street Lighting etc (M,N)	72,269	Nil	72,269	87,259	7,058	37,427	+ 14,990
7 Statutory Undertakings (P)	206,669	Nil	206,669	231,062	5,968	224,428	+ 24,393
8 Prov. and Dayworks (R,S)	299,460	-120,000	179,510	200,208	Nil	196,137	- 95,252
9 Phase II (T,U,X,W)	166,518	Nil	166,518	166,518	1,105	1,332	Nil
10 Tender Basic	10,729,670	-102,355	10,627,315	11,325,581	237,252	10,866,188	+ 591,911
11 Claims (Basic Cost)				108,629			+ 108,629
12 Estimated Total (Basic Cost)				11,436,210			+ 700,540
13 Price Fluctuation				2,565,342		2,362,827	
14 Estimated Total Cost				14,001,552			
15 Outstanding Claims (Basic Cost)				300,455			
16 Price Fluctuation on Outstanding Claims				100,472			
17 Gross Total				14,402,479			

Outstanding Claims (Basic Cost) Line 15 is total claim value submitted by the Contractor less amount allowed in Claims (Basic Cost) in Line 11.

Price Fluctuation is based on an annual rate 12% per annum.

PROJECT E

The project consisted of the construction of a high quality conference centre in the centre of a city.

A Government Department acted as the Promoter (Client) during the design and construction phases.

The project was built under a management contract.

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List of Abbreviations Used

1. Nature of Project
2. Client/Users
3. Management Organisation
4. Contract Control System
5. Causes of delays and cost increases
6. Effectiveness of Contract Control System
7. Comment and Recommendations for Improvements
8. Appendices

ABBREVIATIONS USED

SPECIAL TO THIS REPORT

Client	Public Authority
Users	Government Departments
MT	Management Team
DT	Design Team
DS	Client's Directorate Secretariat
PM	Client's Project Manager
CO	Client's Contract Officer
MC	Management Contractor
CS	MC's Construction Site Staff
MC's PM	MC's Project Manager
CCP	Contract Cost Plan
TMS	Tender Method Statement of Sub-Contractors
FSP	Final Cost Sketch Plan
SWO's	Site Work Orders
VDU	Visual Display Unit

STANDARD ABBREVIATIONS

SO	Supervising Officer
RE	Senior Resident Engineer
QS	Quantity Surveyor
M & E	Mechanical and Electrical Consultants
C of C	Conditions of Contract
B of Q	Bills of Quantities
VO's	Variation Orders

PROGRAMME YEARS

Year (-5)	Feasibility Study
Year 0	Appointment of MC
Year 1	Commencement of Project's Construction Phase
Year 5	The completion date of the MC's contract was for January of Year 5.

The project had to be ready for September of Year 5.

PROJECT E

1. Project's nature

1.1 Purpose of the project

The purpose of the building was to provide high quality accommodation for international conferences organised by various Government Departments (Users).

In order to serve its purpose the building had to be fitted with:

- equipment and finishes complying with international standards
- internal and external communication links using the most advanced technology to date.

The building had to be ready for use on a certain date, approximately five years after the commencement of the construction, in order to accommodate an important international conference.

1.2 Technical description

The layout of the site of the project is illustrated in appendix 1.

The accommodation comprised of:

- an auditorium
- five conference rooms of various capacities
- press, radio and TV facilities
- restaurants and offices
- car park

The building was air conditioned and had sophisticated high quality electrical installations.

The works comprised of the following:

- a. The fitting out, including all services within an existing structure below ground level, which housed a telephone exchange.
- b. The fitting out within an existing structure of the building's basement and car park (3 floor levels below ground).
- c. The construction of the building's concrete superstructure comprising of 8 floor levels, approximately of 60 x 50 m on plan, and 65 m high, and an approximate floor area of 27,000 m².

Reinforced concrete of grade 40 N/mm² was used for the construction of the frame, floors, roof, cores and the wall adjacent to existing buildings.

I. Frame

Frame to south part of building built off existing low level structure, with structural link formed by means of high tensile steel starter bars set in deep mortices in roof of existing structure to the north off a new raft and columns constructed in Contract 2.

2.4 and 2.5 m deep, Diagrid beams spanning above the Auditorium and the principal Conference Rooms of Level 6. These diagrids had to be propped until the structural frame completed.

Formwork to the cantilever construction at Level 7 also had to remain in position for an extended period until the structure to Level 7 was complete.

Level 6 and 6M slabs suspended from 2.4 m deep cantilever beams by hangers each comprising of 3 x 32 mm \emptyset Macalloy bars encased in 40 mm thick Mendovil fire protection with an outer skin of stainless steel.

Steel portal frame to Conference Room 5 , plant room and tank room. 1800 deep steel trusses off a concrete perimeter beam to Conference Room 5.

Bush hammered/point tooled exposed granite aggregate white concrete (40N/mm^2) to main cores. Cantilever beams all main and secondary columns, the bottom one third of the diagrid beams and the expressed Level 6 slab edge. Remaining concrete was of Portland cement mix as struck from lined formwork.

II. Horizontal surfaces

Five types of horizontal surfaces were used:

- Flat slabs. Solid reinforced concrete slabs 200 mm thick.
Some slabs, such as the floor to the plant room, were 400 mm thick.
- Waffle slabs. The waffle slab floors had ribs at 800 mm centres each way and their thickness ranged from 300 (100 + 200 mm) to 600 mm (200 + 400 mm).
- Diagrid floors on Levels 5 and 7.
- Macalloy suspended slabs.
- Articulated slabs with 30 mm expansion joints on either side.

III. Columns and walls

All columns of the superstructure were in white concrete with a bush hammer finish.

The wall to the adjacent existing building was of a varying thickness reinforced concrete with a 25.50 mm flexell expansion joint between the wall and the adjacent building.

Exposed internal walls of the service cores were in granite aggregate case against lined formwork and subsequently bush hammered.

IV. Roof

Roofs generally of reinforced concrete construction cast on lined formwork and of similar construction to floor slabs.

Coverings consisted of average 75 mm cement and sand screed to falls, 3-layer asphalt, extruded polystyrene insulation and pre-cast concrete paving slabs and pebbles.

Sloping roof over Levels 6 and 8 accommodation was reinforced concrete construction 200 and 250 thick with 75 x 50 sw treated battens with 500 mm insulation with 19 mm marine ply with insitu Code 6 lead with rolls at 600 centres.

Roof to Conference Room 5 consisted of steel latic beams with an outer surface of aluminium on decking with sealed units including vapour barrier and insulation and inner skin of 25 mm plaster on metal lath with profiled soffit suspended from it.

Expansion joints at both edges of articulated slab between north and south parts of the building to be 30 mm wide.

1.3 Complexity of the project

Choosing the right method of construction was a complex task because of the project's location (restricted site in a busy town centre), its purpose (high quality, completion before a certain date and design changes due to technical innovations) and its complex structure.

Advance planning of construction techniques were therefore required and the following examples illustrate some of the constraints and complexities of the project's construction.

a. Restricted site.

- I. Because of the restricted size of the site, careful planning was required in order to arrange the various stages of construction. For example, until the area a. (appendix1) of Level 3, ground

level was prepared, eighteen months after the commencement of the construction, the site offices had to be moved around a number of times.

Advance purchases of materials were also difficult as those had to be stored elsewhere.

- II. The perimeter of the building was kept within the building line, as it was determined by the adjacent to the project existing buildings.

Levels 6 and 6M had to be extended beyond the building line in order to accommodate the two main conference rooms on Level 6. Macalloy suspended slabs were chosen, the formwork of which had to be supported from the ground for approximately 21 days until the concrete reached satisfactory strength. Thus the supporting scaffolding restricted the site even further.

- III. The building was surrounded by busy and rather narrow streets. It was therefore important that coordination with the police was assured when heavy construction traffic was likely to obstruct the traffic flow. eg the police had to be informed well in advance of pouring concrete.

- IV. Noise levels had to be contained in order to minimise disturbance to surrounding buildings and thus the:

- removal of existing concrete elements had to be carried out by diamond core drilling and hydraulic bursting instead of using compressed air pressure tools
- percussion tools used for bush hammering had to be jacketed

b. Existing building in the basement.

- I. The reinforced concrete elements in the sub-structure had a number of constraints which dictated the method of working. The most important of these constraints was the continuation of the

existing telephone exchange which had to be protected against flooding and the requirement of continuous piling in the building's southern portion (in order to meet the time schedule).

These constraints necessitated working in a number of areas concurrently.

- II. Part of the building was founded on the existing structure while the remaining was founded on undisturbed ground.

The building was therefore built in two independent sections joined by an articulated slab capable of coping with vertical as well as horizontal movements due to differential settlement.

c. Building's design.

- I. The building contained a number of areas free of columns and double storey spaces (conference rooms).

The variety of slabs proposed by the design for those areas required careful planning in choosing among the alternative formwork systems to be used.

- II. High quality white concrete. Only a small number of specialist sub-contractors could deliver the high quality finish of white concrete required by the design. (In the pre-selection stage the sub-contractors were asked to demonstrate the quality of their work by building a section of a column on the site before they were allowed to tender for the works of the superstructure frame). The production of white concrete also presented problems because suppliers could only deliver the aggregate specified in the design in single size. Thus in order to produce the white concrete from an established plant, 3 no storage bins were required, two for the aggregate and one for the Blackpool sand. Because of the long period over which the white concrete was required, a separate batching plant had to be set up on a different site to

produce white concrete exclusively for the building. The separate plant also had the advantage of ensuring a supply of the material with no chance of contamination.

III. Design choices of electronic systems such as telephone systems, satellite communications, etc, had to be taken as late as possible in order to make full use of technological innovations.

d. Time constraints

Walls could have been constructed using slip formwork techniques because the building's height exceeded the minimum economical lift of 25 - 30 m. This system was not used however because of the time advantage that would have been lost in the programmed floor cycle of 10 weeks at Levels 5 & 7.

Instead height shutter fabricated in steel on traditional materials was used.

1.4 Project s implementation programme

The Management Contractor (MC) was appointed in May of Year 0.

The completion date of his programme was January of Year 5. (The Client estimated that he needed 3 months to furnish the building after it had been handed over by the MC).

His contractual programme was divided into two parts:

- the pre-commencement phase, from date of appointment to April of Year 1
- the construction phase which, from April of Year 1 to the end of the construction period.

The Client's own current operations, ie fittings of equipment, directly

purchased and installed by the Client were planned to commence in January of Year 4, and be completed in April of Year 5. There was therefore a safety margin of approximately four months before the international conference (mentioned in para 1.1) which was scheduled for September of Year 5.

Before the commencement of the construction phase the Client awarded two contracts, the works of which were not included in the MC's scope of works.

Contract 1 was for the construction of a diaphragm wall along the site's boundary line.

Contract 2 was for:

- the excavation of the buildings northern side (see appendix 1)
- the construction of the frame of the building's basement over the undisturbed north side

Contract 2 was completed in April of Year 1 with a delay of seven and a half weeks, for the reasons explained in para 5.2.

Prior to the MC's appointment the following design stages had been completed:

- A feasibility was prepared in June of Year (-5)
- A preliminary design (sketch plan stage)
- The final sketch plan was prepared in June of Year (-1) . The final sketch plan contained the layout planning of the building, decisions on materials, and the structural analysis of the building
- The working drawings (ie detailed concrete design, architectural finishes, and coordination of services) had already commenced.

Our observations started in April of Year 1 and were terminated in the summer of the following year.

1.5 Cost estimate

The total cost of the building in Year 0 prices was estimated at approximately £26m. (The fees of the MC and the design costs were not included in this estimate).

Out of the total cost, £0.252m were allocated for the substructure, £8.4m for the superstructure, £16m for the fittings, furnishings and M & E works, and £0.6m as a contingency.

A more detailed account is shown in Appendix 2.

The total cost in out turn prices was estimated at £50m, including furnishings etc.

2. Client/User

2.1 Client's nature

The Client was a public Authority responsible for the design and construction of the project.

A number of public authorities such as Government Departments, Broadcasting Authorities etc (Users), were consulted in relation to several design requirements and specifications.

The Client's organisation relating to the project appears in appendix 3.

The Directorate Secretariat (DS) had to approve the project's scope of design, the time schedule and conditions of the MC s contract (C of C). The DS was also in communication with the Users in order to coordinate design specifications.

Budget or contractual time over runs had to be approved by the DS.

The Project Manager (PM) was a senior member of the Client's staff. His main objective was to exercise financial and time control in order to complete the project within the approved by the DS, contractual time schedule and budget.

In order to fulfil his duties he had been allocated a contingency (explained in para 4.2.2.2c) which he could use at his discretion when he was faced with problems requiring design alteration, acceleration of the works etc.

The PM as a position, had been created from the early stages of the

project's design, but due to retirements, three senior members of the Client's staff had been appointed successively. The third PM was appointed for Year 1. (but had already been involved with the drafting of the MC's C of C) and was expected to remain as a PM to the end of the construction phase.

The Contracts Officer's (CO) duties were to ensure that the appointments of sub-contractors, payments (final and interim) and extension of contract periods were carried out in accordance with the established legal procedures of the Client.

The PM's and CO's duties are further analyzed in para 3.2 under the title of Management Organisation.

The Client had also appointed a member of his staff as the Resident Engineer (RE). The RE was directly answerable to the Supervising Officer (SO) who was the leader of the Design Team as explained in para 3.2.

2.1.2 Sources of the project's finance

The project was financed from the Client's budget, ie from public funds.

Budget increases were likely to be financed either by the Client's contingency (reserved for all the projects the Client undertook) or by the Users, if such increases had occurred as a result of changes requested by the Users.

The annual expenditure budget was reserved by the Client based on annual forecasts, in out turn prices, submitted by the PM six months prior to the commencement of each financial year.

It was therefore important that the forecasts were as accurate as possible because:

- in case of overexpenditure the DS would have to meet the increase from his contingency
- in case of underexpenditure, funds could not be transferred to the project's budget of the following year.

2.2 Client's expectations, objectives and attitude

2.2.1 Expectations

The Client's expectation was to build a prestigious building for the purpose described in para 1.1 which:

- provided facilities above set international standards
- when finished would be completed with the most up to date electronic equipment
- was completed for a big international conference in the autumn of Year 5.

The design brief to the Design Team (DT) illustrates the Client's quality expectations.

The main aim was to design a building which in its inside answered the complex requirements of an international conference building efficiently, humanely and imaginatively, and which, on its outside, formed a worthy and positive fourth side to a square consisting of buildings of different architectural periods, respecting its neighbours without being overwhelmed by them.

The interpretation of the main design aim can be summarised as follows: respect the height, scale and siting of neighbouring buildings and

select external materials in sympathy with them; arrange the accommodation at each floor level to meet the functional and the security needs of the building; arising from this, site the Main Conference Area about half-way up the building and on one level only - this level forming the principal floor and projecting beyond those above and below it in such a way that its roof corresponds in height and character (although not in style) with adjacent building's roof; provide natural shading, where possible, with roof overhangs or external louvres; make the internal planning reasonably flexible by using a framed structure with the minimum of load-bearing walls; give everyone in what is a deep-planned building good access to natural light and views, of the surrounding buildings.

2.2.2 Client's objectives

Because of the building's prestigious nature and the small time margin between the completion and fitting time of the building and the date of the first conference (see para 1.1) the Client weighed the inter-dependent variables in the following order:

time, performance, cost

In relation to cost, the Client expected the PM to try to achieve savings wherever possible, but he was also willing to increase the budget in order to improve quality, purchase the most advanced equipment or accelerate the works to meet the programme.

2.2.3 Client's attitude towards the project's management

The project's design was not carried out by the Client's in house design department because of the technical complexities involved.

A multidiscipline Design Team (DT), consisting from professionals provided

by specialist consultancy firms, was engaged by the Client to carry out the design.

The Client had not engaged a Management Contractor (MC) before. Indeed, up to Year (-1) the DT was preparing the design and tender documents on the assumption that a conventional contractor was going to be appointed.

The Client decided to choose this type of contract for the following reasons:

- a. Under this contract the Client has the flexibility to introduce design changes or take decisions concerning design details or specifications during the construction phase, with less time or cost consequences than under a conventional contract.
- b. The Client felt, and the DT agreed, that because of the project construction complexities, the DT would benefit by the MC's professional advice in relation to construction methods.
- c. In Year 0 when the MC was appointed, the future of the project was uncertain and the date of commencement of the works unknown. The decision to allow the project to proceed and to reserve the required capital in the Client's budget had to be taken by the Government.

Because the available time for the construction was diminishing, it was doubtful that a conventional contractor could have met the contractual completion date.

It was therefore decided to divide the construction phase into two stages, precommencement and construction, and to appoint the MC to proceed with the first stage.

A special power clause applicable for the first stage was included in the MC's C of C. Thus if the Cabinet had decided against the project, the Client could notify the MC of the contract's termination. The MC would then be entitled to costs incurred within the following fourteen days after the receipt of notice.

It was also felt by the Client that the construction stage under a MC would be shorter than under a conventional contract because of:

- (i) the overlapping of the detailed design and construction
- (ii) the quicker pace the works would be carried out due to the MC's tight management of design information and site resources.

The PM, CO's, DT's, and MC's authority, duties and responsibilities are explained in para 3 which follows.

3. Management Organisation

3.1 Management Team

The project's MT was located on site and consisted of the PM, DT and the MC's site personnel.

Following the MC's appointment the principal members of all the participants in the MT were brought together for a two day conference, away from the site and their offices, to meet each other in informal discussions.

The DT consisted of the following disciplines:

- A firm of Architects
- Structural Engineers
- M & E Engineers
- A firm of Quantity Surveyors (QS)
- A team of public health engineers
- Accoustics Consultants
- Estate Surveyors

A junior partner of the Architect's firm was appointed as the DT's leader and was named in the C of C Superintending Officer (SO).

The MC's site staff , called the Construction staff (CS), operated under the leadership of a Project Manager (MC's PM) and an assistant Project Manager.

The CS was divided into five units shown in appendix 4, under the leadership of:

- a Project Engineer (overall leader)
- a Construction Manager

- a Coordination Manager
- a Planning Manager
- a Project Surveyor

The lines of communication between the three members of the MT appear in appendix 5.

3.2 Delegation of authority and duties of the MT's members

The division of the responsibilities between the PM and CO are listed in the table of appendix 6.

Briefly the PM's duties can be summarised as follows:

(i) In the design period:

- Supervision and approval of final designs, as those were submitted by the DT (following the approval of the DS).
- Approval of cost plans and overall construction programme prepared by the QS and MC.
- Approval of expenditure of pre-ordering and pre-purchasing materials.
- Approval of pre-tendering lists prepared by the MC and DT (only for contracts worth more than £10,000).
- Approval to accept tenders over the budget.

(ii) During the construction period:

- Approval of deviations from the project's contractual time and budget (with the consent of the DS if cost over runs could not be covered by his contingency).
- Payment of interim and final certificates.

The DT under the SO's leadership was in charge of the quality and cost.

control of the project.

During the design phases of the sub-contracts the SO supervised the production by the DT of the design drawings, specifications and tender documents in order to ensure that they comply with the Client's brief and were produced within the programme targets agreed with the other members of the MT.

In the tendering stage the appropriate member of the DT, in conjunction with the MC, prepared the tender lists. These lists of tenderers for and the award of contracts of less than £10,000 was approved by the SO. For contracts of a higher value than £10,000, the SO instructed the MC to accept the lowest tenderer, in most cases as explained in para 3.3.2, after he had obtained the PM's approval.

During the construction phase:

- the SO and DT were responsible for the execution of the works according to the design standards, and for the control of costs
- the SO's agreement was also required before extensions of the contractual time schedule or cost increases of any sub-contract were approved by the PM
- the SO checked the interim valuations, and issued the interim certificates for payments to sub-contractors.

The final payments were approved by the SO and agreed with the MC before they were paid by the PM.

The SO was responsible for the liaison between the DT and MC (for the issuing of design information requested by the sub-contractors), and the issuing of all the defect certificates to the sub-contractors for

remedial works.

The QS was responsible for the preparation of the cost plans during the project's pre-construction phase. During the project's construction phase, the QS was responsible for the preparation of the financial tender documents, during the tender period of each sub-contract and the monitoring, recocording, control and reporting to the other MT members of costs (see para 4.2).

The Estate Surveyors dealt with problems which arose as a result of damages to adjoining structures during the projects construction phase.

The MC s responsibilities can be summarised as follows:

- (i) During the pre-construction phase he allocated the works to the various packages and prepared the project's time schedule.
- (ii) During the design phase of individual sub-contracts the MC offered expert advice to the DT on construction techniques, costs, preparation of contract programmes and target dates. He also proposed the pre-ordering of materials prior to placing of sub-contracts.

The MC's contribution during the selection of prospective sub-contractors is outlined in para 3.3.2.

During the construction period of let sub-contracts the MC had full control and supervision of construction of the works in accordance with the MC's C of C and the SO's instructions. During this period the MC:

- prepared programmes with the sub-contractors and then monitored them (see para 4.1.1.2)
- prepared a cost breakdown which enabled the QS to maintain an effective cost control

- prepared the interim valuations and forwarded all the accounts of expenditure to the QS in order to prepare the final accounts
- attended meetings with the SO and arranged meetings with the sub-contractors
- established all claims and arranged with the sub-contractors for all defects listed in the SO's certificates to be made good.

In order to carry out his duties, the MC organised his site staff as shown in appendix 4.

- The Project Manager (MC's PM) had total management authority for all the site activities. He ensured that a close liason between the DT and CT was maintained and he controlled and motivated the appointed sub-contractors.
- The Project Surveyor was responsible to the MC's PM and was in charge of the MC's activities in respect of data for financial control.
- The Project's Services Manager was responsible to the MC's PM for the coordination of all services installations and to liasing with the Construction Manager to ensure the services were installed in accordance with the design drawings and specifications.
- The Construction Manager was responsible to the MC's PM for all site activities with the primary function of maximising production for all sub-contractors and for ensuring that works were constructed in accordance with specifications and drawings.
- The Project Planner was responsible to the Construction Manager for all planning, scheduling and associated management aids, including computer control techniques.
- The Project Engineer was responsible to the Construction Manager for the management of all structural work in order to ensure that the structures were erected in accordance with the design drawings and specifications.

The duties of the MC's site staff are explained in more detail in appendix 4.1.

In December of Year 1 the structure of the MC's site staff was changed temporarily to that shown in appendix 4.2 following the bankruptcy of the sub-contractor for the erection of the building's frame. The MC took over the direct control of the bankrupt sub-contractor's site personnel. It was anticipated that after the completion of the frame, the MC's site management structure was going to be reshaped to its original form. In the new arrangement:

- The Assistant Project Manager was responsible for the MC's duties and responsibilities before sub-contracts were let.
- The Project Engineer was responsible for the erection of the frame.
- The Construction Manager for the programming and monitoring of progress of let sub-contracts.
- The Coordination Manager for the coordination and quality control of M & E sub-contracts.
- The Planning Manager was in charge of the preparation and monitoring of sub-contractors programmes in conjunction with the Construction Manager.
- The Project Surveyor was in charge of the MC's activities in respect of data for financial control.

3.3 Types of contract

3.3.1 C of C of Management Contract

The contract was signed between the Clients and the MC. (The C of C had been prepared solely by the Client's engineering department). Under the C of C the MC could not bid for any sub-contracts.

The Management Fee allowed for the entire direct and indirect costs of the organisational, management accounting and other specialist services employed in connection with the Contract, excepting only those described in Schedules A, B, C and D described in appendix 7. The management fee covered the following:

- a. The cost of establishing and maintaining detailed accounts and records of all expenditure on items described in Schedules A, B, C and D and of affording facilities for the examination and checking of these accounts and records by the Quantity Surveyor.
- b. All the charges for rent, rates, taxes, telephones, stationery, heating, lighting, cleaning and all other overhead expenses relating to the Management Contractor's operations and not incurred on the site.
- c. All fees, salaries and other emoluments and all expenses, including the cost of travelling and expenses of the Management Contractor's Directors.
- d. All profits or other expense or remuneration to the Management Contractor including financing charges and costs incurred OFF SITE and not included under Schedules A, B, C or D.
- e. Financing expenses for reserves held by the Authority in respect of sub-contractors or suppliers requiring payment in full prior to completion of the Works.
- f. All bonus payments made to staff employed under Schedule A and B and head office staff.

The MC therefore had an incentive to try and finish the job as quickly as possible because this way he could reduce his overheads (Schedule C) and thus increase his profit.

The sub-contractors C of C's were prepared and signed by the MC ie the sub-contractors were employed directly by the MC. Interim and final payments were paid to the sub-contractors by the MC. The MC was paid as the works progressed on the basis of certificates he submitted to the SO and which were valued by the QS. (Thus in the case of a sub-contractor's bankruptcy the MC carried no financial risks for possible overpayments which could have been made to the sub-contractors).

The MC was directly responsible for the design valuation and control (ie issuing of VO's even if they had financial consequences) of the temporary works. This responsibility had not been included in the MC's C of C's but the PM delegated this authority to him as the works progressed.

A penalty clause had been included in the C of C for delays to the programme but the MC could balance it, if it was ever evoked by the Client, by transferring the penalty on to the sub-contractors who caused the delay. The MC would have to meet the cost of the penalty himself however if delays had occurred as a result of errors attributed to the MC's management.

The MC's incentives to finish the job within the contractual time and try to stop costs from overrunning the budget were not due to the C of C but because:

- he wanted to keep the Client (who was a major promoter) happy, and thus encourage him to undertake more of his future projects under this type of contract
- he did not want to damage his professional reputation in a very competitive market.

3.3.2 Sub-contractor's contracts

The types of the awarded sub-contracts can be grouped into three categories:

a. Measured B of Q's

- fixed price, with no adjustment for price fluctuations, or
- fluctuating prices; prices were adjusted by application of formula based upon official indices

The quantities of those contracts were only adjusted for quantities on an add/omit basis to account for variations.

b. Provisional B of Q's

- fixed price or
- fluctuating prices

The works were being re-measured upon completion, incorporating all variations.

c. Price breakdown schedule/schedule of rates

- fixed price or
- fluctuating prices

The type of contract was decided by the DT and MC and was approved by the PM on the basis of:

- Time length of the Contract. If it was less than a year, the PM preferred the type a. with fixed price.
- Market conditions (amount of similar work on offer etc) determined the strength of the MC or sub-contractor when a sub-contract was negotiated.
- Nature of works of contracts. Price breakdown schedules were chosen when the works could not be quantified. Provisional B of Q's were chosen when the extent of the works could not be defined.

The MC's main problem with the management of sub-contractors was that he had to control the resources (ie labour etc) of another firm.

The means he used in order to persuade the sub-contractors to meet their time schedules were:

- stiff penalty clauses in the sub-contractors C of C
- to black list them from future jobs the MC was involved with, in various parts of the country
- rigorous checks of the sub-contractors previous performance when the selection lists were set up.

The tender procedure was carried out in three stages which are illustrated in appendix 8.

a. Interviews and selection of tenderers.

Initial lists of prospective sub-contractors were prepared by the MC (based on the records the MC maintained at his HQ) and were discussed with the appropriate members of the DT.

Those lists had to be examined and approved by the CO who examined the financial soundness of the candidates and whether the Client's tendering procedures were observed. (For example, the CO checked that all the consultants/contractors registered with the Client were given a chance to tender on a rotational basis, in line with established procedures within the Client's organisation).

The SO was responsible for the coordination of the Client's and DT's views so that comments on the lists were forwarded to the MC within seven days of the issuing of the lists.

The MC if necessary, in response to the comments, issued questionnaires

to the sub-contractors in order to clarify the questions raised, before he produced a short list of maximum six candidates in consultation with the appropriate member of the DT.

Once the short list was approved by the PM, the MC and appropriate members of the DT held interviews with the selected candidates.

The interviews were held in two parts:

- in the first part the scope of the works was explained to the candidates
- in the second part their ability (ie experience with similar works, their workload etc) to carry out the works was examined.

The MC also examined, based on his records (independently of the CO's investigations) the financial status of the sub-contractors. The tender documents were then forwarded to the candidates.

b. Appraisal of tenders.

The sub-contractors financial offers were forwarded to the MC through the PM.

On receipt of the offers the MC forwarded the documents to the appropriate members of the DT (eg B of Q's to the QS, proposed by the sub-contractors specifications of materials/equipment to the SO, M & E etc) for their comments.

The DT's comments were communicated to the MC within a specified by the MC time period at the end of which the MC had to produce a tender report to the SO with his recommendations. Usually the lowest tenderer was chosen unless there were specification discrepancies and the tender had to be reviewed.

c. Placement of order.

Depending on the size of the contract (£10,000) the PM's authority was required before the SO would instruct the MC to place the order. Upon the receipt of the order the MC signed the contract with the successful sub-contractor and a first meeting between the MC and sub-contractor was arranged.

4. Contract Control System.

From the outset of the pre-construction phase the members of the MT worked on the production of a "Procedures Manual". The aim of the manual was to cover the format of various reports and how the cost and time data could be inserted into the computer as the works progressed in order to facilitate such reports.

The manual outlined standard procedures in relation to:

- cost control
- planning
- instructions issued by the SO to MC and then from the MC to sub-contractors
- control of sub-contractors ie tendering procedures and control of sub-contractors after their appointment
- contract meetings
- operational administration eg correspondence, register of drawings etc
- interim and final certificate procedures and cost checking
- computer control.

The first draft of the procedures was produced a few months after the commencement of the construction phase and after several revisions it was finalised in July of Year 2.

4.1 Programming and Progressing

4.1.1 Programming

4.1.1.1 Pre-commencement phase

Prior to his appointment, the MC had included in his management proposal to the Client, a bar chart programme. The programme had been prepared in the limited period available to the tendering MC's and the design

information available at the time.

Following his appointment the MC, in cooperation with the DT and PM, as well as the three sub-contractors who had already been appointed by the Client, (for the windows, the lead panelling between the windows and the lead roofing), concentrated on:

- the preparation of a site layout drawing
- the preparation of a construction programme

a. Site Layout drawings.

The purpose of the drawings was to assist the sub-contractors during the tender stage in the preparation of their offer, and to help them plan their working programme after they have been appointed.

The drawings contained information on the:

- size and outline walls of the building
- site access routes to the site
- office accommodation for common use by site staff (such as toilets, canteen etc)
- temporary services and lighting provided by the MC
- position capacities and radii of the tower cranes
- rubbish disposal facilities etc

The site layout drawing was updated and reviewed as the site developed.

b. Construction Programme.

Appendix 9 illustrates the preparation of the construction programme by the MC during the project's pre-construction phase.

The works were grouped by the MC into 110 sub-contract packages.

In preparing the packages the MC considered the following:

- economic pricing
- control of sub-contractors
- the grouping together of like trades within one package wherever possible. Thus he could achieve minimisation of industrial relations problems particularly due to differing levels of payments and operatives
- the level of expertise and financial capability of the companies he intended to ask to tender
- avoidance of further sub-letting
- special requirements of the authority

The packages were sub-divided into six principal work sections eg superstructure, internal finishes etc.

Following the agreement of the scope of the packages with the DT and their approval by the PM, the MC estimated their duration and target dates of the packages (such as start and finish dates).

Other milestone dates or restrictions to the progress of the works were also identified.

A bar chart containing the 110 packages was produced by the MC and was discussed with the DT and PM.

The target dates did not correspond with the contractual completion date of the MC's contract, but to a stricter programme which the MC and DT thought could be achieved. According to this programme the date of completion of the project was 13 November of Year 4.

The finalised programme was inserted into a computer network.

c. Out To Tender Place Order Schedule.

This schedule was an important document used to control the placing of sub-contract orders to comply with the Overall Construction Programme. It was agreed and distributed to all members of the DT. The document was derived from the construction programme working backwards from the start on site. Durations were established individually for each element covering the following pre-start activities:

- Preparation of Tender Information
- Tender Period
- Tender Appraisal/Recommendation/Place Order
- Development of Sub-contractor's drawings
- Manufacture of Materials/Organise Site Start

The dependence of the activities of these items, together with additional items covering the Tender Interviews/Agreed Tender Lists, were established on a sub-network for each element. This data was then fed into a computer and printouts were made in order of date covering each member of the Team's activities. This enabled only activities in the immediate future to be reviewed instead of sorting through large amounts of paper. Bar chart printouts were also produced by the computer and these then enable heavy workload periods to be indentified giving opportunity for a certain amount of resource levelling to overcome peak periods.

As it can be seen in appendix 10, steps 1 to 4, the Out To Tender schedule was monitored during the meetings between the DT and MC and the SO, MC's PM and PM. (The policy and progress meetings are described in more detail in the following paragraphs).

The first print out of the Out To Tender schedule was produced during the pre-construction phase (appendix 9).

4.1.1.2 Construction phase

Sub-contract packages were put out to tender in accordance with the dates of the out to tender schedule, in the sequence shown in appendix 10 (steps 5 to 9).

At the tender stage see also appendix 8, the tendering sub-contractors were informed by the MC of the contract period, the possible starting dates and other restraints. For example, the sub-contractor for the supply and installation of the air-conditioning chillers was informed of the dates when he could use the crane.

Together with their financial offer, the sub-contractors submitted a Tender Method Statement (TMS) and a strategic appraisal of the works in a bar chart form. In the TMS the sub-contractors demonstrated that they can meet the conditions of contract by explaining their method of work on which their tender was based.

The MC checked the TMS's of the sub-contractors in order to ensure their compatibility and acceptability in relation to the work programme of other on going sub-contractors.

Following his appointment, the sub-contractor was required to prepare a detailed programme in conjunction with the MC.

The programme included the following information:

- Details of all drawings that the sub-contractor will prepare,

allowing time for approval

- Deliveries of principle materials indicating latest dates for ordering
- Periods for manufacture including any mock-ups or required tests
- On site activities in sufficient detail to allow weekly monitoring of progress
- Anticipated weekly labour strengths
- Principle dependencies ie building watertight together with any special plant requirements.

The details of this programme were fed into the computer network by the MC s planner. The construction network was therefore continuously expanding until all the packages have been put out to tender. (Step 10).

4.1.2 Monitoring and Reporting.

The MC ensured that the construction programme maintained by ascertaining that the sub-contractors had adequate site supervision, labour resources, plant and equipment available on site.

After the appointment of a sub-contractor or supplier in addition to his detailed programme he also had to prepare:

- a. Information Required Schedule. It was based on the detailed programme and showed the dates by which the sub-contractor/supplier required design information by the DT and other sub-contractors or suppliers. The schedule was checked by the MC and agreed by the DT.
- b. Short Term Programmes. All the sub-contractors were required to prepare short term programmes every four weeks showing the every day work sub-contractors programme in a bar chart form. The MC set the issuing dates so that all the programmes covered the same period. The short programmes were updated every four weeks but covered a

period of eight weeks (or longer in some areas in order to cover the full time span of an activity).

Based on the short programmes the MC ensured workability and practicability on site (ie no interference between the sub-contractors) and that the sub-contractors were in line with the construction programme.

c. Special Area Programmes. In certain circumstances, sub-contractors were required to prepare additional detail programmes. For example if a sub-contractor fell behind, he was required to show how he intended to get back on programme.

Based on the above schedules, the MC could identify the interface activities of sub-contractors/suppliers and problems which could arise because of interference between the sub-contractors/suppliers involved during the implementation of the interface activities.

Progress was reviewed during regular meetings held on site between the MC and every sub-contractor/supplier. Items relating to progress which were discussed during the meetings are:

- Flow of information against the Information Required Schedule
- Ordering and delivery of materials and items to be fabricated off site against the detailed and Short Term Programmes
- Off site testing
- Industrial Relations and Labour
- Actual progress of the works.

During these meetings the MC and sub-contractor/supplier could therefore:

- agree, once problems had been identified, on practical working arrangements, definitive responsibilities for finished work and measures for

avoiding potential disputes

- monitor the sub-contractors/suppliers' progress against the detailed and short programmes and establish reasons for delays and their practical solutions.

The progress information from the meetings was used by the MC's planner as input data for the revision of the network steps 11 to 13 in appendix 10 illustrate the above mentioned procedures.

4.1.2.2 Coordination of the Management Team

4.1.2.2.1 Meetings

- a. Progress meeting between the members of the DT and the MC in order to coordinate the flow of information required by the MC before packages were put out to tender.

These meetings were taking place every two weeks on a fixed day ever since the MC was appointed.

- b. Pm's briefing meeting. Three days after every Progress meeting the SO and the MC's PM met the PM in order to report to him on the progress of tendering of sub-contracts, problems, and propose solutions arrived at during the progress meeting. The PM finally approved programme changes arising from a.

- c. SO's monthly meeting. The MC reported to the SO on the progress of the packages currently under construction. Besides the MC and DT, representatives of the sub-contractors also participate in the meeting. The PM or his assistant were also present.

- d. RE's site meeting. Every week the RE chaired a meeting with the MC's engineers during which they tried to solve technical problems and the works for the following week are planned.

- e. Coordination meeting. This meeting between the site managers of the

MC, and the sub-contractors took place in order to try to finalise the arrangements of the services, ie ducts, electricity mains, etc.

Problems not clear on the drawings could therefore be identified and decisions as to the exact location of the services were derived during the meeting.

4.1.2.2.2 Control documents. (Output of the time control system).

1. Print out. The computer could be instructed to produce a print out of the network activities in the form of a bar chart.

On the print out each activity had a reference number which consisted of eight digits. The first four digits referred to the number of the sub-contract package the activity was part of. The first and fifth digits referred to the principal work section. The last three digits were specific numbers of the activity.

The location of each activity with reference to the level and the quadrant of the level (eg Level 2 quadrant NE) appeared next to the description of each activity.

A bar chart next to the description showed the duration of the activity at daily intervals. The critical activities were noted by the letter C. The non critical activities were shown to commence on the earliest starting date. The earliest start of each activity and its duration were also shown arithmetically at the end of each bar.

The print out was used by the SO and MC's senior site managers as a planning tool especially when changes to the programme were introduced because they could see the activities likely to be affected.

2. Medium Term programme. These programmes covered a period of three months and were updated by the MC's planner every two months. The programme was in bar chart form and showed significant target dates evolved from discussions with the relevant sub-contractors and from the sub-contractors own detailed package programmes.

This programme brought together and coordinated the activities in detail of all such contractors working on site at any given time.

3. Short Term programme. This programme covered a period of six weeks and was updated every four weeks. It was in a bar chart form and showed day to day activities. It was based on the sub-contractors own short term programmes. They were mainly used by the RE, Site Managers etc, to coordinate the planned activities of all the sub-contractors working on site at the same time.

The PM did not normally receive it, but he did receive it on request in order to carry out a spot check on the progress in a particular area. Possible questions he may have, he could then solve immediately with the MC's PM.

4. Contract programme. This bar chart programme was manually produced. It contained 80 sequential stages; the commencement and finishing dates of which are determined by the contractual period of the MC's contract. Each of these stages consisted of a number of activities of the overall network. The code numbers of the activities contained in each stage could be found by instructing the computer to print the codes of the first and last activities contained under the stage's title. The computer could then be instructed to print the codes of the activities between these two code numbers.

The Contract Programme was used by:

- the MC when he reports on progress during the policy meetings to the PM and SO
- the RE when he reports on progress to the PM
- the PM when he reports to his superiors every three months.

The programme was first included in the MC's management proposal submitted at the end of Year 0. It was based on the vague information provided to the tendering MC's during the pre-tender period. The MC updated the programme during the pre-construction phase when information was more defined. A review of the programme took place when the commencement date was fixed.

5. Target programme. The target programme was also a bar chart but it was based on the dates included in the overall construction programme.

It contained the same sequential stages as the contract programme. The critical path was marked on this chart.

The target programme was referred to during the site meetings between the MC, RE and sub-contractors, and fortnightly progress meetings between the MC and MT.

After it was first produced, during the pre-construction phase, the programme was readjusted in order to accommodate the inability to supply the design information by the dates expected. When the commencement date became known, the programme was updated. The programme was later changed once more at the RE's request because he disagreed with some of the assumptions.

6. Contract Monitoring Reports. They were manually prepared every month by the RE and distributed to the PM and SO.

The report contained information on:

- Physical progress
- Amount of labour provided by sub-contractors
- Difficulties during the past month
- General report on the progress of works
- A list of various work packages with their contractual start and finish dates
- Progress in relation to the construction programme.

The PM used the report to:

- Report to his superiors every three months. The information provided in the report is checked against the contract programme.
- Check the progress of the works against the medium or short term programmes ie problems stated in the report could initiate a spot check by the PM as explained under the heading of short term programmes.

7. Target Programme Progress Report. This report was presented by the MC and was discussed during the SO's monthly meetings. The MC reported against:

- Target bar chart
- Sub-contract programmes

8. Bar chart extracts. Print outs of specific packages or parts of packages.

4.2 Cost Control System

4.2.1 Objectives of cost control system

Planning, monitoring and control of costs was the responsibility of the QS, who carried it out in consultation with the MC.

The objectives of the system were:

- a. To keep the Client, the rest of the DT, and the MC informed at all stages of the estimated out turn MC's final account with regards to:
 - current decisions concerning design scope of all packages, including additional or omitted works
 - all information available on cost trends
 - inflation
 - contractual entitlements submitted or pending
- b. To advise and guide the Client and DT by early evaluation of the comparative cost implications of:
 - alternative design and construction problems
 - other proposed variations and instructions
- c. To ensure that information was available at the right time to enable the Client and DT to keep within the budget.

In order to fulfil the above objectives, the cost control system designed by the QS and MC comprised of:

- i) A frame reference. This was the Contract Cost Plan (CCP), described below, which indicated the allocation of approved funds allocated to each package and the level of prices on which it was based (base prices).
- ii) A Financial Review of the CCP. This was a report of the total anticipated costs, per package, to completion which incorporated:
 - A feed back system which involved the recording of all the financial commitments to date and the forecasting of all the foreseeable changes

to future commitments (output).

- A remedial financial adjustment based on the system's output information.

Funds could be transformed within the CCP or the total of the CCP could be changed, as problems occurred or changes were initiated. This involved the analysis of the CCP in categories of committed and uncommitted funds, and within those categories the identification of sections and subsections of funds of varying degrees of rigidity in respect of amount and application.

4.2.2 Operation of the cost control system

4.2.2.1 Preparation of CCP in the pre-commencement period

Prior to the pre-construction period, ie before the Client decided to appoint the MC, the QS had prepared a Final Sketch Plan estimate (FSP), in accordance with the Client's standard procedures.

The total cost estimate of the FSP was distributed among 20 elements, and it was being refined as the design advanced and more information became available.

Following his appointment, the MC, in consultation with the DT, agreed on the scope of works of the 110 sub-contract packages mentioned in para 4.1.1.6. Once the works of each package were defined, the QS proceeded with the preparation of the CCP as shown in appendix 9.

The cost of each package was estimated based on estimates of the latest FSP ie the estimates of the 20 elements were analysed by trade and the cost of the works of each package was estimated.

The cost estimates of the preliminary works, which had been included in the FSP as provisional sums, were checked by the MC and were allocated into the CCP by the QS, as it is shown in appendix 9.

The CCP was finalised by the QS in January of Year 0 and it was approved by the SO and PM two months later.

As it is shown in the same appendix, the CCP was being discussed and adjusted as the tender documents for the first packages in accordance with the Out to Tender document, were being produced by the SO, QS and MC.

During the pre-commencement period the MC also prepared a brief network, using the target dates of the construction network which in combination with the costs of the CCP, was used as a payment cash flow prediction. (See below).

4.2.2.2 Description of the CCP

The CCP was prepared to show the target amounts allocated to each agreed sub-contract package under Schedule D and other elements, as appropriate, under Schedules B, C and E.

Following these amounts there were four additional items:

- a. Design and price risk contingency, approximately 2.5% of the total cost estimate of the CCP. This allowance was used at the discretion of the DT (with the SO's approval) to:
 - increases in the cost estimates of unlet packages due to minor design developments. High increases were covered by PM's contingency or were asked to redesign
 - offset tenders above the package's cost allowance

In cases where the difference was too high the PM was requested to cover it from his contingency or the PM requested the SO to redesign the item or repeat tender.

- b. SO's contingency, approximately 2% of the total cost estimate of the CCP. This contingency covered increases of costs due to VO's issued by the SO after a package had been let. The VO's initiated by the Client however were covered by the PM's contingency, or by the Client's departmental budget contingency (or by the User who had requested it).
- c. The PM's contingency. The amount of this contingency was not known to the rest of the MT and it did not appear in the CCP. The estimated costs of VO's initiated by the PM or cost increases covered by the PM's contingency for the reasons explained above, were quoted in the Financial Review.
- d. Forecasts of total inflation and VO costs on the project as a whole. A contingency for price variations due to inflation had not been included in the CCP. The Client's computer forecasts of inflation had been used to provide an inflation budget covering the duration of the project. This was included in the Financial Review. The amount of inflation due to be paid to date, calculated in accordance with price adjustment formulae was shown in the Financial Review as part of the total inflation budget, the balance of the total budget representing future inflation.

The CCP was entered into the computer and formed the basis against which all future cost monitoring and reporting took place.

The QS and MC also prepared a cash flow forecast on a month by month basis and on financial year basis (April to April) for capital expenditure

and gross expenditure ie including projected inflation, VO's and assuming that all contingencies had been committed during the contract period.

4.2.2.3 Control of costs during the project's construction phase

The QS in conjunction with the MC monitored the CCP to take account of design development, variations, tenders received, market trends, re-appraisal of provisional allowances and estimates, examination and estimate of alternative methods in design solutions and means of execution, and inflation trends on which the Client advised when required.

1. Checking and control of sub-contractors' tender offers

The procedures and control of costs carried out during the tendering of a sub-contract are illustrated in appendices 8 and 11.1.

The QS proceeded with the preparation of the B of Q in accordance with the out to tender schedule. Design details and possible changes were forwarded by the SO.

The cost estimates of the tender documents were checked by the QS against the CCP. The SO, MC and PM were informed in writing about the cost estimates, the discount of the expected tender, the effect on the the design contingency etc. The PM's approval to proceed with the tender was required if the recommended tender by the MT exceeded 10,000 or the estimated allowance in the CCP.

When the tenders were returned, the SO, MC and QS met in order to evaluate the offers. Their recommendations were reported to the PM, in accordance with the procedures described in the MC's C of C. (The procedure differed for contracts of a value higher than £10,000).

In either case if the tender offer was higher than the CCP then the PM had to decide whether to repeat the tender or meet the additional cost from his contingency.

When the sub-contractor's appointment was approved the QS adjusted the design contingency and recorded the sub-contract sum into the Financial Review against the CCP allowance.

2. Control of costs during the sub-contract's construction (see appendix 11.2)

The control of costs during the construction of the sub-contract concentrated on the control of VO's issued by the SO.

In the Procedures Manual eight categories of VO's had been identified: (They had to be recorded separately)

- a. Prime cost sums
- b. Provisional sums
- c. Changes due to inflation. For the pre-tender period the costs in the B of Q were deflated to prices of the first quarter of Year 0 using the Client's formulae.

The cost of inflation during the sub-contract's construction phase was calculated, when appropriate, depending on the type of C of C (see para 3.3.2), using price indices provided by the Client.
- d. Changes in Client's requirements. (using PM's contingency). Changes of the Final Sketch Design indicated by the Client and for which there was no provision made in the estimates for design development.
- e. Changes in estimated amount of work to be done. (SO's contingency)
ie changes of design initiated by DT, excluding changes due to reasons covered by d, f, g.
- f. Changes in estimate of the cost of the works (SO's contingency).

These were classified broadly as corrections of estimates in the light of further information about the work.
- g. Changes due to unforeseeable circumstances (SO's contingency), such as adverse site conditions not revealed by site investigations, bank-

ruptcy of sub-contractors, industrial actions etc.

- h. Claims by sub-contractors or including expenses under contract condition (PM's contingency). Cost increases due to claims were registered under the category of their cause.. However in some cases it was not practicable to classify and make the attribution to the other categories and unassigned sums were shown under category g. When the claims were finally settled they were transferred to the appropriate category.

In the Procedure Manual the following procedure for issuing VO's was proposed (see appendix 11.2):

- When a VO was issued by the SO to the MC a copy was received by the QS

Any major VO's or optional design changes were evaluated, prior to issue by the QS.

Upon receipt of a VO the MC decided which sub-contractors the instructions related to and issued an instruction to each one as necessary. A copy of each sub-contract package instruction was received by the QS. (Step 3).

In addition to the formal VO's issued by the SO the RE issued Site Works Orders (SWO) covering minor site initiated changes to the works. These were again forwarded to the necessary sub-contractor by the MC. At fortnightly intervals all SWO's were confirmed by a covering VO to the MC by the SO, who likewise issued formal instructions to the sub-contractors. (Step 5).

upon receipt of a VO the QS valued it and inserted the costing into the computer register (see 7 below) of costed instructions for the quarterly Financial Review and monthly/fortnightly interim statements (see systems output below).

The SWO's were issued to the QS in triplicate for costing; one copy for QS files and the remaining two were costed and returned to the RE and SO for information regarding the level of commitment..

- The MC had to provide the sub-contractor regularly with a statement which recorded all the instructions issued. Sub-contractors were invited to cost and agree that the statement represented an up to date position as far as their contract was concerned, or ammend objectively if they did not agree, so that matters in dispute could be dealt with expeditiously. Failing agreement, a reference was made to the sub-contract agreement or supply agreement.

The QS monitored the MC's net costs. (Step 6):

- The MC advised the QS before any major expenditure on items of direct costs were committed.
- The MC's net costs chargeable under the Contract Management C of C were checked monthly and were distributed into appropriate headings for the purpose of allocating expenditure and calculations of the adjusted CCP.

3. System's input information

Appendix 11.2 shows how the Financial Review was updated by the QS during the construction phase of the the sub-contracts.

The updating and redistribution of the contingencies was based on the QS's evaluation of committed expenditure (step 9)

The QS for his evaluation of the committed expenditure relied on:

- a. The estimated evaluation of the issued instructions by the SO and the distribution of their estimated cost effects among the various packages, which was described under the heading of "control of costs".

The effects of the VO's were reviewed during the biweekly meeting

with the SO.

b. The estimate evaluation of claims.

As it is shown in step 7, the MC informed the QS at regular intervals on:

- The claims which had been settled
- The valid, in his opinion, claims which had been submitted by the sub-contractor. The MC stated the amount claimed and discussed with the QS the likely settlement. The precise sum was defined by the QS in accordance with the sub-contract conditions.

In addition to this the QS tried to establish the following procedure in order to improve the estimated effects of issued VO's and accelerate the settlement of claims.

The QS sent a statement listing all the issued instructions to the sub-contractor every two weeks.

The sub-contractor returned the forms with his estimated cost increases although at this stage there was no commitment on their side that these cost estimates could not be adjusted in the future.

During monthly meetings between the QS and sub-contractor claims etc could be discussed and perhaps settled.

This procedure had not been fully developed at the time of our research and thus its effectiveness is not known.

It was also appreciated by the QS that as the number of sub-contractors working on site increases it will be difficult for the QS to cope with

the detailed costing of all the instructions and thus he would have to concentrate on VO's with major cost implications.

- c. Interim and final valuations of works were carried out every two weeks by the QS and MC.
- d. Anticipated impending variations and requests for additional entitlement. (Planning of costs).

In addition to assessing the cost and time effect of issued drawings and instructions, the QS in consultation with the MC, assessed the cost effect:

- of anticipated impending variations and of requests from sub-contractors for additional entitlement or
- where such requests have been received, the anticipated amounts at which they were expected to settle.

For these purposes it was the responsibility of the PM, the DT and the MC as appropriate in each case, to keep the QS informed, as early as possible of impending or anticipated variations, additional payments and other events affecting costs which have not been shown on issued drawings or instructions or recorded in meetings or correspondence copied to the QS.

These items were discussed between the QS, SO and MC during the cost review meetings.

4. System's output (Reports)

- a. Cost reports to the SO were available every two weeks and were discussed during monthly meetings between the QS and SO. Any significant cost changes or anticipated cost changes however were reported to the PM as and when they occurred.
- b. Cash flow forecasts on a six month basis were included in the cost report.

- c. The "Formal QS's Report" was produced quarterly and coincided with the PM's meeting.

In the pre-commencement period this report was produced every two months. The formal QS's report contained:

- the CCP allowance and base
- the CCP allowance for inflation. (This allowance was estimated based on the Client's predicted annual inflation prior to the commencement of the financial year)
- the tender sum
- authorised changes, ie VO's
- the amount of inflation, of any accepted tender
- provision for future inflation

5. Decision making meetings

- a. Cost review meetings. The monthly report was discussed during monthly meetings between the SO and QS, regarding the update of VO costings.

The purpose of the meeting is to monitor the actual expenditure of the contingencies and decide on advice to the PM.

- b. Monthly meeting between PM and SO.

The SO met the PM three days after the cost review meeting had taken place, in order to report to him on expenditure of the contingencies.

Any problems likely to result in overspending were discussed and action was decided upon.

- c. Policy meetings. During these quarterly meetings between the PM, SO QS and MC the MC with the cooperation of the DT produced a report which contained a summary of progress, financial data etc. The summarised financial data were based on the "QS's Formal Report".

The purpose of the meetings was to make all the participants aware of costs, progress against the time schedule etc.

6. Other meetings related to financial monitoring and control

- a. Evaluation of tender offers. The SO, QS and MC met when tender offers were returned in order to evaluate them and recommend selection to PM.
- b. Biweekly meetings between the QS and MC in order to discuss the cost effects of the SO's instructions.
- c. Monthly meetings between the QS and major sub-contractors discussed in sub section 3 of para 4.2.2.3

7. Computer applications

The MT appreciated that a project of this nature would make beneficial use of a computer back-up system to project management. Assistance could be given to recording, displaying and monitoring the Cost Plan, the Out -to Tender Place Order Schedule, the Master Programmes, Drawing Schedules and Labour Schedules.

The computer system was working in conjunction with the Client and Design Team. A VDU was located in the Head Office of each MT member.

The hardware and software requirements were:

- Three VDU's were located at the Site Offices for use by the Team.

- It was essential that the system for flow of information and demand on processing took into account the quantity and ease of input.
- A structured data-base system helped to control the files and records.

Advantages of a computer system:

- a. Ease of recording, updating and reproducing general data.
- b. Ability of computers to sort data according to operator's requirements.
- c. Ability to carry out repetitive standard analysis.
- d. Capacity to carry out "What If" analysis, to assist with policy and strategy decisions.

The MC established the following files, with access available for all members of the DT.

Contract Details:

Basic contract information including professional team details, critical contract dates etc. Sub-contract element details. Central files of processed data critical to policy and decision-making.

Design Information:

Drawing Control. Project Instruction Control. Technical reports etc.

Costing Information:

Overall Cost Control. Elemental breakdown and cost distribution. Cash flow files. Variations control. Weekly contract cost reporting. Increased Cost Analysis.

Project Management:

Out-to-Tender Place Order Schedules. Master Programmes. Key Date Programmes. Network Analysis. Short Term and Detail Programmes. Programme Updating. Labour Records (including security requirements).

5. Causes of delays and cost increases.

A number of problems had been encountered during the first two years of the project's construction phase; some of them delayed the programme or their additional costs had to be met by the PM's contingency if delays were to be averted.

Some such problems are described below.

5.1 Liquidation of a sub-contractor

The sub-contractor who had been awarded, in February of Year 1, the sub-contract for the erection of the concrete frame went into liquidation in Dec. of the same year. His contract's total tendered value was for £5.5m and its duration for approximately three years.

The sub-contractor's financial strength had been vetted during the selection period by the CO and MC according to the procedures explained in para 3.3.2, a few months prior to his appointment. None of these investigations gave any warnings to the MT that the sub-contractor's financial state presented any problems.

The sub-contractor had set up a site office, manned with his own personnel, but had sub-contracted the actual construction of the works, eg the reinforcement bar supply bending and placing, the supply of ready mix concrete, the scaffolding etc.

A few months prior to his bankruptcy the sub-contractor started to fall behind his programme. This was attributed by the MT to usual inefficiencies of sub-contractors (eg provision of limited resources etc), and the sub-contractor was urged by the MC to increase his resources in order to

improve his performance.

In September however rumours about his financial position started to reach the MT and by November those problems became apparent when cheques started to bounce, site personnel were not paid etc.

Intensive consultation took place among the members of the MT, and it was decided not to terminate his contract unless the receiver was called in. As a temporary arrangement the MC guaranteed direct payment to the suppliers and to his site staff for three months ie until February of Year 2, by which time the MT hoped that the sub-contractor could have improved his financial affairs.

Once the sub-contractor called the liquidator the MT acted promptly. A letter of termination of the sub-contract was sent by the MC within the same day the bankruptcy was announced.

Following the letter the works were stopped for two days until the measurements of the completed works and the materials on site were carried out by the MC and QS.

The MC took over the management of the sub-contractor's works (see para 3.2) for an additional fee fixed after negotiations with the Client.

5.1.2 Effect of bankruptcy on the project's construction programme

The erection of the frame was critical to the overall construction programme. The actual bankruptcy did not cause any delays because the works did not have to stop and be retendered, as would have been the case under a conventional contract.

The delays due to the sub-contractor's slow progress prior to his bankruptcy, estimated in several weeks, were eliminated following a revision of the target programme by the MT.

The following two activities, which originally had been assumed to be critical to the overall programme, were overlapped with the construction of the North and South units of the building:

- Originally the DT, based on expert advice, had specified to the MC that the articulated slab had to be constructed after all the levels of the frames of the two units had been erected. As the works progressed and settlements were recorded it was realised that the settlements were considerably smaller than expected. It was therefore decided that the articulated slab be constructed in parallel with the erection of the two frames.
- A two floor clearance was required between the level under construction and the level where the M & E services were being installed in order to achieve water tightness.

The MC proposed to the MT and the PM approved, to commence the installation as planned, although there was not the two floor clearance, and protect the M & E installations by sealing the floor ie close the openings etc. Thus the overall construction programme would not be delayed.

5.1.2 Cost increases due to liquidation

Before the MC took direct control of the sub-contractor's works, a number of contractors were approached by the MC to bid for the works. The lowest offer was however for an additional cost of £2.2m (to the bankrupt sub-contractor's original offer) and a time extension of 22 weeks.

At first the MC estimated that the total cost rise, if he was to assume direct responsibility, at £3m.

This estimate was later revised to £1,5m and by March, as the effects became more apparent, (for example the suppliers agreed to carry on the supply of materials at the agreed with the sub-contractor prices) the additional cost was estimated at £0.800m.

This extra cost was attributed to:

- i) The increase of the MC's fee because of:
 - the extra cost of the sub-contractor's site staff's administration and for the restructuring of this site staff, which in the MC's opinion, was inferior by the MC's management standards
 - additional overheads eg the MC had to employ additional staff at his HQ in order to administer the purchase of material.
- ii) The additional cost of the sealing of the floors.
- iii) The Client agreed to pay the sub-contracts suppliers/sub-contractors for supplies or works they had carried out and for which they had not been paid by the bankrupt sub-contractor (even though the Client had already paid the sub-contractor for them).
- iv) The Client had to pay for the wrong estimates eg for temporary works etc, in the sub-contractor's tender offer, and which were previously the sub-contractor's risks.
- v) Costs occurred because various arrangements had to be made in a hurry in order not to stop the works eg the receiver did not allow the sub-contractor's site personnel to work on site for some time. Thus the MC had to provide replacements, until the receiver discharged the personnel from other sites.

Some savings were achieved however such as in the case of the supply of steel. (The MC, because of his nationwide activities, agreed rates lower than those of the sub-contractor).

5.2 Inclement weather

The total delay to the project's programme by summer of Year 2 was estimated at approximately nine weeks:

- One and a half weeks were lost when works were stopped due to inclement weather during the construction phase
- The remaining delay was due to flooding in the telephone exchange during the works of contract 2 which delayed the commencement of the construction phase by seven and a half weeks.

5.3 Delays of design decisions or design changes by the Users

The Users had to be consulted by the Client (DS) before the standard of finishes and fittings of certain areas was decided.

The fitting of four TV interview studios, the provision of a satellite communication link and the extension of the telephone exchange were three such items.

5.3.1 TV Studios

The studios were located on Level 1. They were to be used for personal interviews of conference participants. For the fitting of the four rooms the Client was faced with the following alternatives:

- a. To allow the BBC and ITV to fit their rooms according to their specifications at their own expense. The ITV's standards were lower than those of the BBC. A fee would be paid to them when other TV companies used the rooms.

- b. The Client to fit the rooms according to international specifications as it was stated in the design brief. The international specifications were of a higher standard than the BBC's.

The cost of the broadcasting equipment had not been included in the budget.

- c. The Client to provide the empty rooms and the TV companies to equip them every time they used them. If this solution was to be adopted, cables would be run through the building from vans parked outside.

A decision had to be taken by July of Year 2 when the activity of fitting the rooms became critical. As this decision was not reached by then, the PM, in order not to delay the works, decided to make provisions, by providing ducts etc in order to accommodate the possibility (a).

5.3.2 Satellite Communication Link

The link was subject to continuous technological innovations. Its specifications had not been decided by the Client.

The building design permits possible layout changes which were likely to result when the type of link was decided. (False floors, ducts etc).

This activity also became critical by July of Year 2. The decision had to be taken by the Directorate Secretariat in consultation with the Users.

Because the Users had not appointed a Manager for the operation of the building, the PM had to be in contact with the Users in order to collect their views and advise the DS accordingly.

5.3.3 The extension of the telephone exchange

In the design brief a certain area had been allocated in the building's

basement (north side) for the extension of the existing telephone exchange.

Based on the information provided by the User of the exchange, the M & E calculated the heat emission from the equipment in the extension. Part of this heat was planned to be recycled through the building and the remaining heat was to be emitted into the atmosphere through vertical chimnies.

The cost of the extension was budgeted for by a different directorate of the Client.

In November of Year 1 the User requested, through the DS, to allow more space for future expansion. The DT had therefore to estimate the additional heat of the possible expansion and how it could be discharged or recycled since enlargement of the chimneys could cause alterations to other design elements. Possibilities of recycling the heat under the open air podium where ceremonies were likely to be held and thus control the temperature were examined by the DT.

At the beginning of Year 2, requests forwarded to the DS by the User indicated to the PM that the space for future extension was not likely to be required. (Future equipment as a result of progress in electronics were likely to be of a smaller capacity).

5.4 Changes initiated by the Client

A number of design changes were requested by the Client as a result of technical innovations. Such changes resulted in cost increases because of:

- the direct cost of the works
- the cost of disruption to ongoing sub-contractor's works due to late

- information, omission of works etc
- changes of layout or use of areas
 - extra fee for design changes to the DT

The following example illustrates the effects of such changes:

Facilities for linking the five conference rooms, one auditorium, and one press briefing room with the outside world in twelve languages (ie 84 simultaneous outlets) and interlinking the rooms with each other had to be provided. When the transmission means (ie telephone, telex etc) are taken into consideration it was estimated that a system capable of handling approximately 7,000 simultaneous outgoing and interlinking transmissions was required.

A computerised system capable of handling such a number of calls was expected to be developed by the time the project was completed.

In Year 2 the MT was faced with the task of finding a suitable area within the building for the installation of such a computer unit.

It was decided that a room on Level 1, originally allocated as a store area was going to be converted into suitable accommodation for the installation of the computer unit ie install an air conditioning unit, improve finishes etc, at the additional cost of £60,000.

A store area was to be provided on Level (-3), in the area which was originally allocated for the extension of the exchange.

Additional expenditure was also required for the conversion of this area eg provision of fire installations etc.

5.5 Delays because of the restricted access

The police could not provide the required manpower for the closure of the access roads at a date programmed by the MC for pouring concrete, because of other commitments.

Alternative dates had to be examined by the MC and police. The pouring could not be delayed beyond the programmed date. The PM therefore agreed to pay the extra cost due to overtime, so that the date was brought forward and the pouring was carried out over a weekend.

If at that date the pouring could not take place due to inclement weather the PM carried the financial risk.

6. Effectiveness of the Contract Control System

The PM believed that the control system's success was that as a result of the continuous cost and time monitoring and forecasting:

- advance warning of problems was given and thus the MT was in a position to take corrective action
- the PM had a comprehensive picture of the progress to date and was therefore in a position to report to the Client/User initiated changes.

In the following paragraphs the time, quality and cost implications for the Client and the management performance (planning, monitoring and control, of cost and time) under a management contract are compared to the management performance of a conventional contract.

6.1 Time

The PM believed that under a conventional contract the completion date could not have been met because the DT could not have prepared the tender documents before the end of Year 1 ie the contractor would have been appointed in Spring of Year 2.

In the PM's opinion, the construction phase could have started even earlier if the MC had been appointed when the Final Sketch was completed and had been put in charge on contracts 1 and 2 (see para 1.4).

Such an early appointment was not possible in the case of this project because of the uncertainty surrounding the project's source of finance and indeed the project's implementation.

6.2 Quality

- a. The management contract was suitable for this type of project because

it allowed the Client the flexibility to initiate design changes during the construction phase with less time or cost consequences than under a conventional contract. It was important however that the PM made the Client aware that delay of decisions or initiation of changes after the construction had progressed beyond a certain stage would be very costly.

- b. There was no input by the MC into the choice of design specifications because the PM and DT believed that there was a conflict of interests between the MC's objective to complete the project quickly and the Client's wish to build a prestigious building.
- c. The PM and SO were aware that achieving quality standards of finishes was likely to be more difficult under a management contract mainly because the MC has to control the labour force employed by other firms. Similar problems can be experienced of course under a conventional contract, between the main contractor and nominated sub-contractors.

The PM and SO tackled this problem:

- through a thorough screening of prospective sub-contractors during the selection period. For example when the sub-contractor for the frame was to appoint sub-sub-contractors for the supply and pouring of white concrete, prospective candidates were asked to produce on site specimens of their work.
- by establishing their authority from the very early stages of the construction phase. eg Sub-contractors were asked to demolish badly finished concrete even though it was located in the basement.

The result was that very few remedial works had to be ordered because the sub-contractors were made conscious of the standards they had to achieve.

6.3 Costs

The PM believed that a number of cost increases or savings occur under a management contract, as compared to a conventional contract; but on balance the management contract is a costlier way of building a project because of the higher supervision costs due to:

- the MC's fee
- the higher fees paid to the members of the DT in order to compensate for the higher supervision costs they have to undertake under a management contract eg more paperwork, peaks of work load because the MC had front loaded the out to tender schedule, production of considerably more tender documents etc.

The PM felt however that these additional costs were partly offset by the financial gain the Client had by directly sub-contracting all the works of the project.

In the PM's experience, under a conventional contract, every part of the works the main contractor sub-contracts directly, was agreed at approximately 2.5% less than the contractor had quoted in his tender offer to the Client.

6.4 Planning, monitoring and control of time and costs

i) Time

The PM believed that because of the MC's presence the planning, monitoring and control of the target and contractual programmes was more accurate.

It is possible however that some friction, and possibly hostility may occur between the MC and DT, especially in the first stages of the construction phase. Such friction is likely to occur when slip ups

against the out to tender schedule are reported by the MC.

In the PM's opinion such tensions can be relieved during informal meetings between the members of the MT (no minutes are taken) during which the participants are looking for solutions to problems and not responsibilities. If, despite those meetings, no solution can be reached, then the PM felt that it was his prerogative to ask the employing firms to relieve of their duties the individuals who caused the problem.

In this project the PM pointed out that a very good relationship among the MT members had been maintained, mainly because all the members of the MT were aware of the project's complexities and they therefore welcomed the MC's expertise of construction.

Occasional delays during the tender cycles occurred, especially during the project's pre-construction phase, but decisions for corrective action was reached during the informal meetings.

ii) Costs

It may be argued that the total cost estimate contained in the CCP was less accurate than a cost prediction based on the priced by a conventional contractor B of Q, because of the cost estimates of the unlet packages it contained. (Provided that the B of Q did not contain a high proportion of PC and provisional sums).

It was therefore possible that differences could occur between the estimated actual tenders received because of the market conditions at the time of tenders. For example, some major contractors did not tender for the erection of the frame package because they did not want to work under a MC. Thus the offers received were higher than allowed for in the CCP because of the limited competition.

The PM pointed out however that the net overall over/under estimates

as compared to actual tenders were negligible compared to the cost increases due to reasons mentioned in para 5.

Monitoring the committed costs and forecasting the total costs was more accurate than it would have been under a conventional contract, but slower. This was because:

- AIs, verbal and written, were recorded by the QS soon after they were issued by the SO. This is not always possible under a conventional contract where the QS is informed of AIs especially the verbal ones, considerably later after their issuing.
- The actual evaluation of the AIs by the QS was more difficult and time consuming because of the large number of sub-contractors and B of Qs which are likely to be affected.

The PM believed, from his experience with to date, that under a management contract the number and the sum of claims was considerably smaller because of the fragmentation of works into smaller, and thus more manageable packages.

7. Comments and recommendations for improvements

The reasons why the Client changed from a conventional contract to a management contract were outlined in para 2.2.3.

The PM believed that a Client should choose a management contract, as opposed to a conventional contract, if time was of the essence. If building a project at a minimum cost was the Client's primary objective, then a MC should not be appointed.

In the PM's opinion, design and construct or cost plus fee contracts would have been unsuitable for this project.

- a. Design and construct. The Client had built a number of projects under this type of contract.

In the PM's opinion, unless the Client can specify the project's technical specifications prior to tendering, the finished projects are of a poor quality. Thus such a contract was not considered, by the Client, suitable for this prestigious project.

- b. Cost plus fee. The PM's experience with cost plus fee contracts was that unless the Client applies tight control on the decision making concerning the design scope or changes to the design scope, considerable time and cost overruns are likely to occur.

Such tight control was difficult to be achieved in this project because of the number of Users and the established direct lines of communications between the Users and members of the DT (explained below) and the uncertainty of whether the same PM could be in charge of the project to the end of the construction phase.

The PM however made a number of comments relating to the Client's involvement with the project which, in his opinion, the Client should consider in order to derive benefits from a management contract.

7.1 It is important that the Client should appoint a senior member of his organisation, ie with considerable experience of how the Client operates and of building projects, as a PM from the project's conceptual phases to the project's commissioning.

During the project's construction the PM's duties may be summarised as follows:

- Provide leadership to the MT so that the design scope is materialised and the balance of the cost, time performance, interdependant variables is maintained in accordance with the Client's wishes and slip ups to the programme due to flow of information are avoided. A contingency sum placed at his discretion will allow him to finance the tackling of unforeseen technical or external problems
- Keep the Client informed at regular intervals of the project's progress, committed costs and forecasts
- Advise the Client on the implications of design changes (initiated by the Client or Users). The decision to implement them however should always lie with the Client
- Ensure that the MT is informed of such changes and implements them
- Avoid delays to the programme, by ensuring that decisions required to be taken by the Client are made within the dates indicated in the programme.

7.1.1 The PM can therefore fulfil his role only when all the information or decisions for action between the Client (Owner or Users) and MT are filtered through him.

In this project a two way direct communication link existed between the

Users and members of the DT, throughout the project's design phase, (prior to the MC's appointment) and during the pre-construction phase and first year of the construction phase.

Because of those links the Users could contact members of the DT directly and request them to investigate design changes without the SO's knowledge. For example one User asked the M & E to investigate the provision of an interpretation system different to the one which was proposed in the design specifications. The M & E investigated and reported directly back to the User in relation to the cost implications of the proposed change, without the knowledge of the DS, PM or SO.

In March of Year 2 the DS, on the PM's recommendation, informed the DT through the SO that:

- When a member of the DT received such a request, the SO had to be informed he informed the PM who could refuse.
- The results of the investigations were then reported to the DS by the SO, via the PM who then decided with the User whether the change should be implemented. The extra cost involved was either met by the User or by the Client's general budget.

7.1.2 The appointment of the building's manager should be carried out

at the beginning of the design phase ie when decisions relating to the building's function, standards etc are taken. In this project the Users had not appointed a manager although the DS had stressed his importance.

The existence of the building's manager would have helped the PM when design decisions, such as those in para 5.3, were to be taken because he would only be dealing with one person (ie decisions would be consistent and be taken quickly).

7.1.3 The PM pointed out that it was important in a complex building of this nature that the PM is supported by additional staff from the Client's organisation. (Either on a part/full time basis depending on the work load). For example in this project a M & E was involved with the project on a part time basis when changes were initiated by the Client for the telephone links etc. His duties were to prepare the brief of those changes by researching the methods available in the market, before the alternatives were evaluated by the DT and MC.

7.1.4 The PM felt early in the pre-construction phase that it was advantageous if he did not participate in the progress meetings (see para 4.1.2.2.1) ie when conflicts between the DT and MC were likely to arise when slip ups to the out to tender place order schedule occurred.

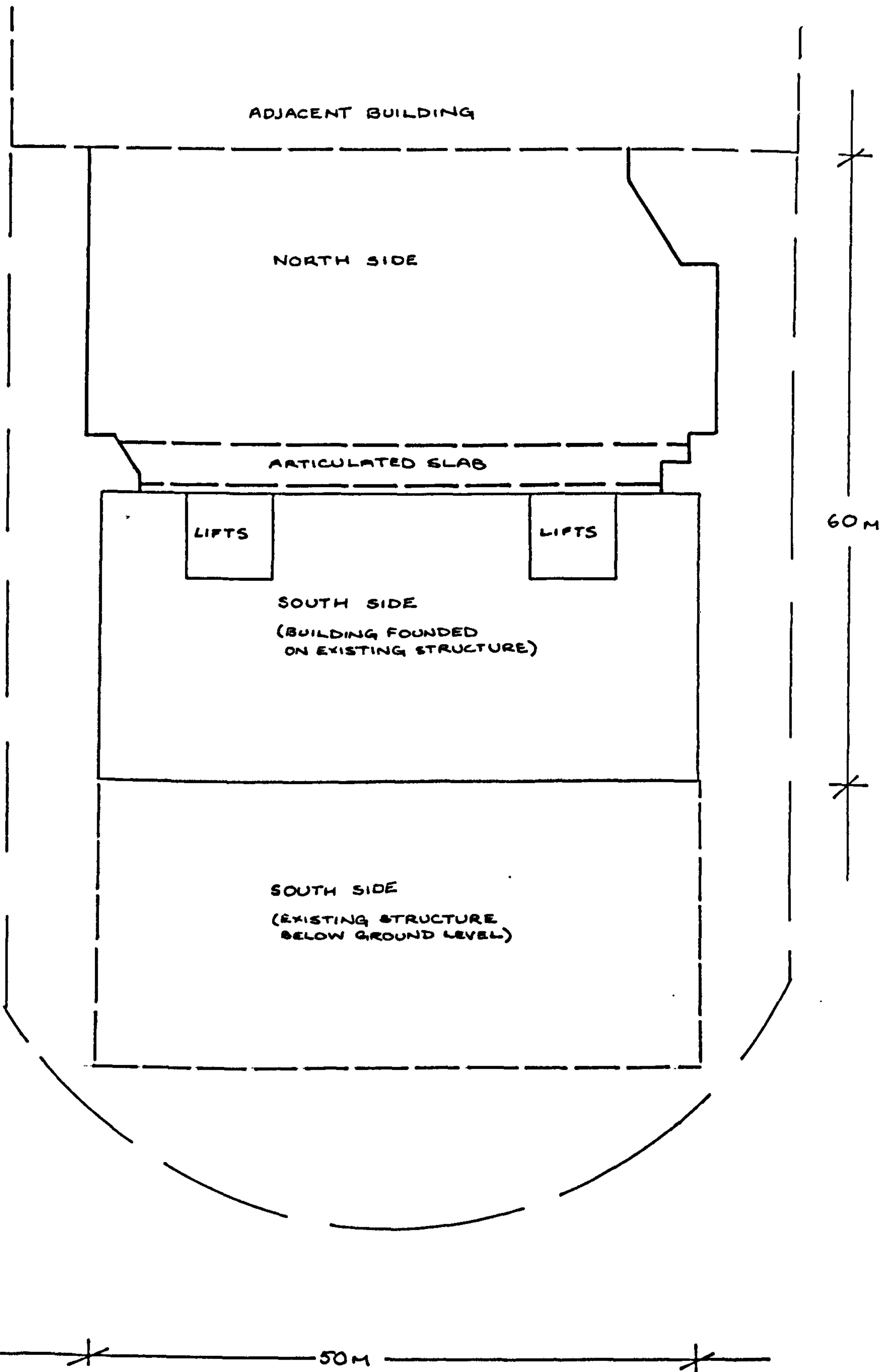
In the PM's opinion if he was not present in those meetings the DT and MC would feel free to discuss the problems and agree on action, instead of spending their time in endless arguments in their effort to defend themselves for the delays.

When the PM and MC's PM reported to him, the PM also felt freer to apply

pressure on either of them to speed up the selection cycle, so the dates were met. (In some cases the PM following this meeting with the SO and MC's PM, would try to go directly to the member of the DT or MC's site staff who was causing the delay in order to speed up the procedure. It should be noted however that tracing the people responsible was in some cases difficult).

7.2 The PM believed that there should be no liquidated damages clause for delays etc, in the MC's C of C's with the Client. The sub-contractors would then be employed directly by the Client and not by the MC. The PM believed that without this clause the MC would concentrate on finding the most favourable solutions for the Client when there were cases of time over runs because he could not be liable for paying penalties (ie the PM believed that the MC's professional reputation, and his wish to win more future contracts awarded by the Client were good incentives for the MC to try and satisfy the Client).

PROJECT'S SITE PLAN



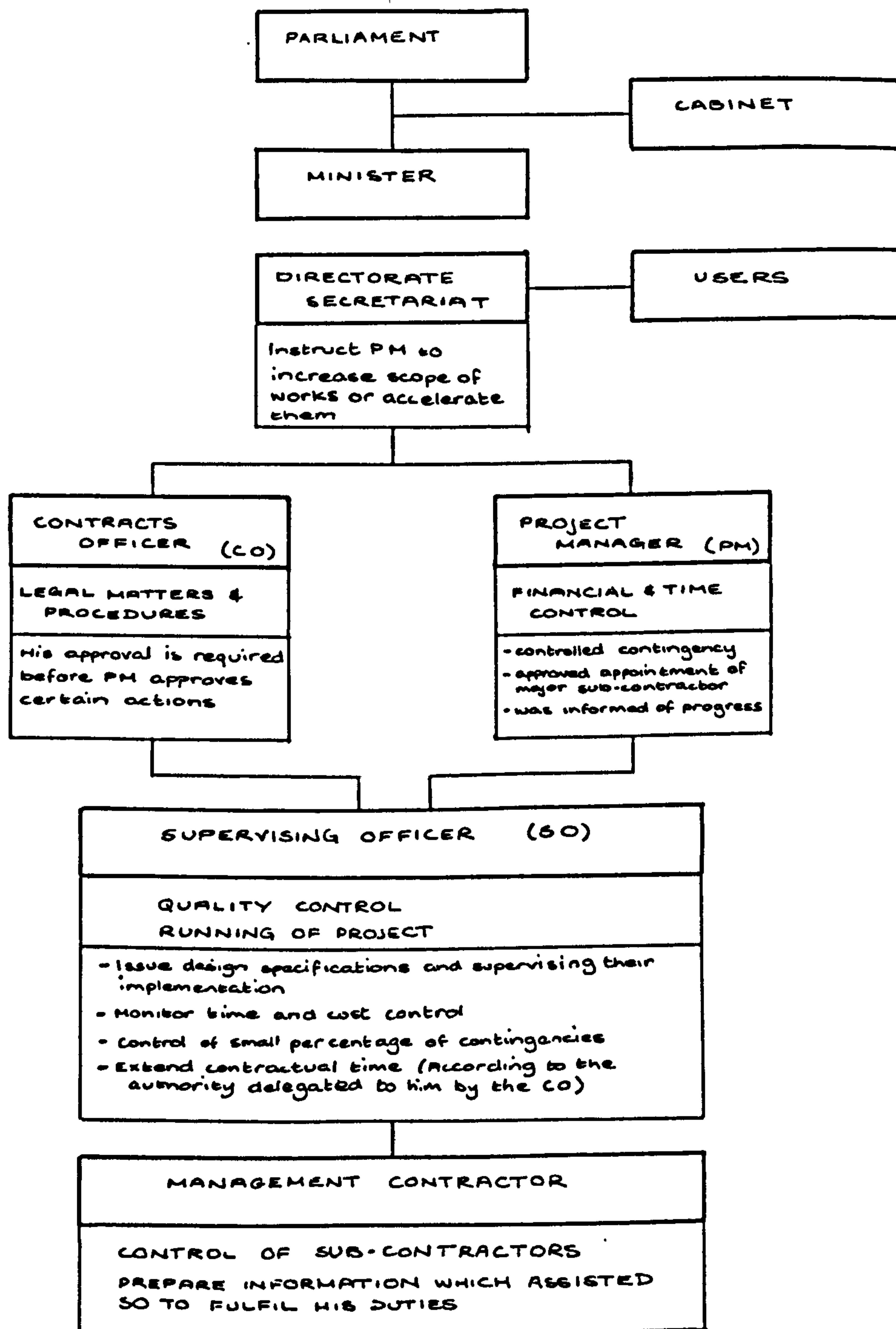
- BUILDING FOUNDED ON EXISTING STRUCTURE
- BUILDING FOUNDED ON GROUND

OUTLINE COST PLAN AND SPECIFICATION NOTES

<u>Element</u>	<u>Cost</u>
.....	£
Substructure	252,395
Superstructure	
2A Frame	1,992,457
2B Upper Floors	1,679,750
2C Roof	433,889
2D Stairs (excluding finishes)	102,401
2E External Walls }	
2F Windows }	2,202,295
2G Internal Walls	875,825
2H Doors	1,073,099
.....	8,359,716
Internal Finishes	
3A Wall finishes	1,273,945
3B Floor finishes	709,425
3C Ceiling finishes	431,310
.....	2,414,680
Fittings and Furnishings	620,626
Engineering Services	
Mechanical Eng	4,999,462
Electrical Eng	2,975,297
Lifts	752,942
BWIC	499,960
Profit & Attendance	699,925
Sanitary, Plumbing & Rainwater	197,800
.....	10,125,386
Drainage	166,829
External works	821,687
Storeys Gate Double Glazing	13,396
.....	1,001,912
Common Services	3,320,322
Contingency	612,063
	<u>£26,707,100</u>

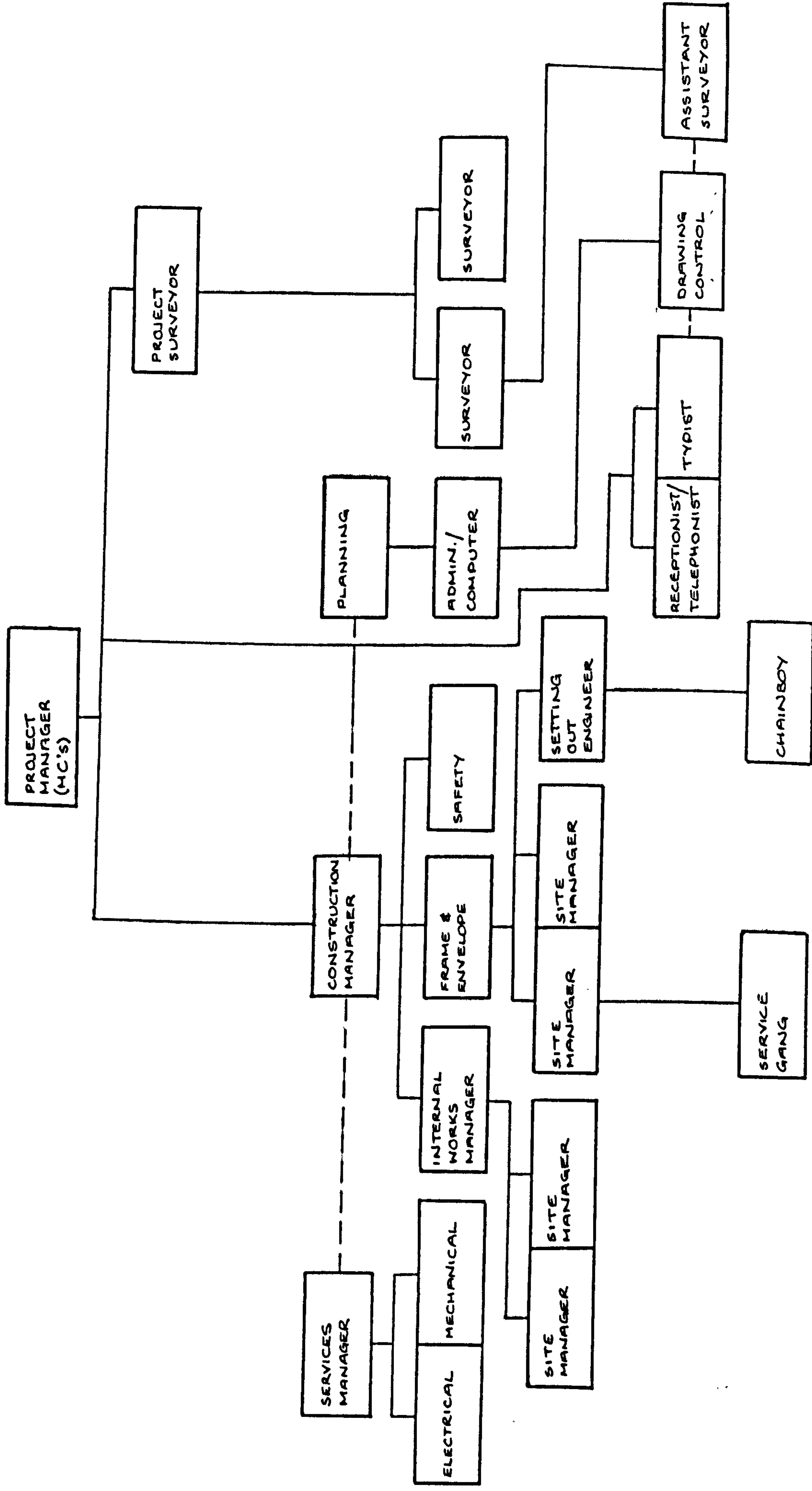
MANAGEMENT STRUCTURE

DELEGATION OF AUTHORITY AND DUTIES DURING CONSTRUCTION PHASE



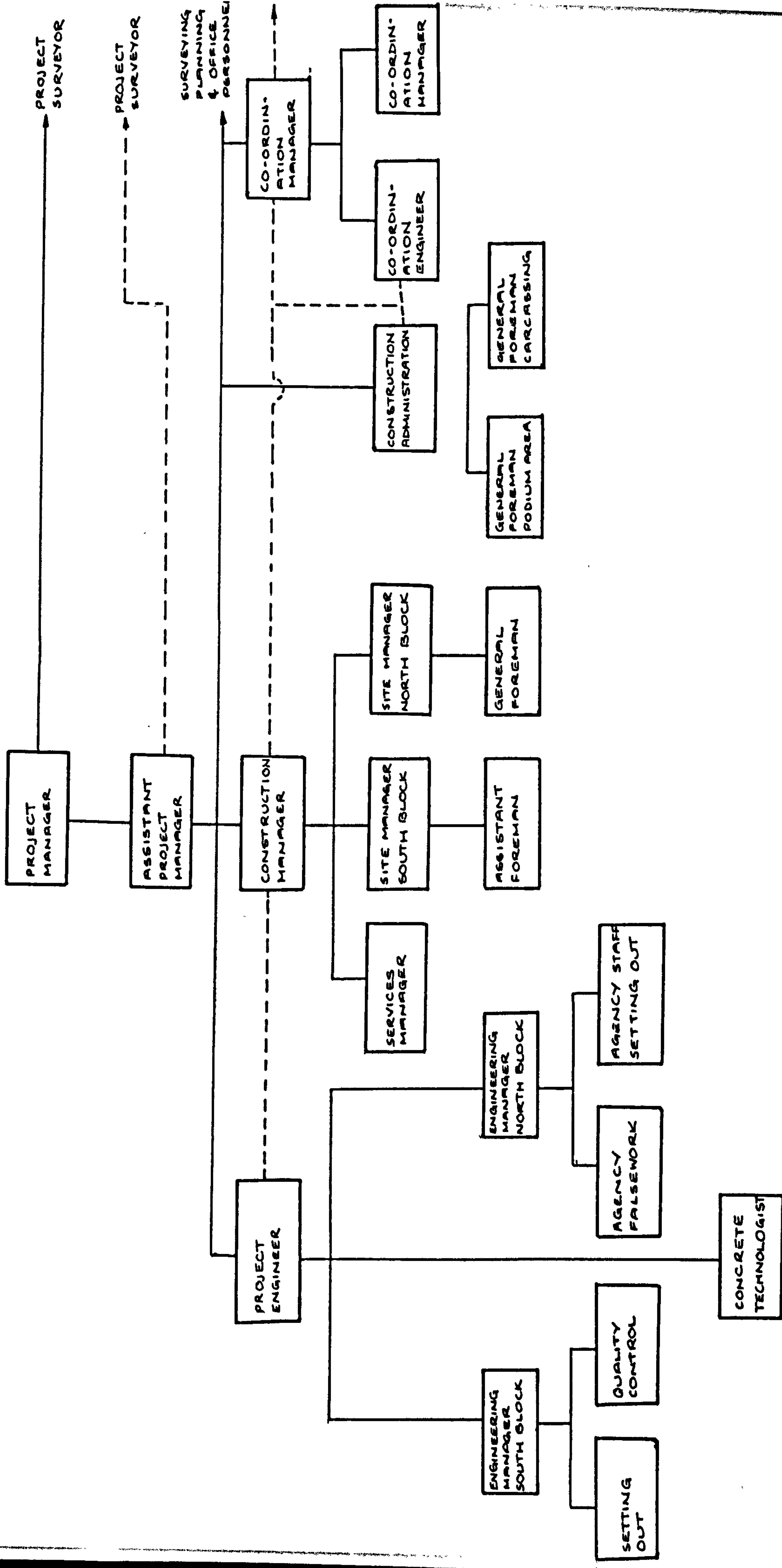
MC's SITE MANAGEMENT STRUCTURE

APPENDIX 4.



MC'S SITE ORGANISATION

APPENDIX 4.1



The Site Based Team of MC

Project Manager

He was responsible for the following:

- The setting up and monitoring of all operational control systems.
- Establishment of all meetings and for maintaining effective communications with all parties.
- Site safety, welfare and safety. He ensured that good industrial relations are maintained by all sub-contractors.
- He was available during both the pre-construction Phase 1 and construction phase for advice and consultancy on all matters affecting the project and for utilising the support resources of Bovis Construction Limited.

Project Surveyor

He was responsible for the following:

- The preparation of all Tender Documentation required from Bovis for all sub-contract packages of work and supply contracts and for liaising with the Project Design Team in the analysis of tenders and recommendations in this respect.
- Collation and preparation of all valuations, payments to sub-contractors processing of variation orders and final settlement of sub-contractor's and suppliers accounts.
- Together with the Project Design Team, the preparation of financial statements and cost breakdowns, financial graphs and related information as may be required during the currency of the contract and for the preparation of the final account.

Project Planner

He was responsible for the following:

- The introduction of the appropriate planning procedures, computer scheduling and visual control documents. He maintained a continuous liason with the Design Team, sub-contractors and suppliers and the management team to ensure that all restraints were properly reflected in the building programmes.
- In conjunction with the Project Surveyor, the establishment of practical divisions of sub-contract packages and for defining demarcation of responsibility.
- He was available during the pre-commencement stage to develop and prepare all necessary design and construct programmes.

Project Engineer

He was responsible for the following:

- Setting up base lines, level grids and datums for the project and for maintaining a continuous checking procedure as the construction developed. The maintenance of proper records and surveys for all completed structural work.
- Controlling all aspects of concrete quality, including mix design, analysis, testing and for the implementation of proper techniques of mixing, placing and curing. Checking and approving formwork techniques in respect of erection, propping and striking and the design of temporary works.
- In association with the Design Team he undertook inspections of all on-site and off-site pre-cast concrete casting and steelwork fabrication and establish with the selected sub-contractor acceptable delivery and erection sequences and methods.

Project Services Manager

He was responsible for the following:

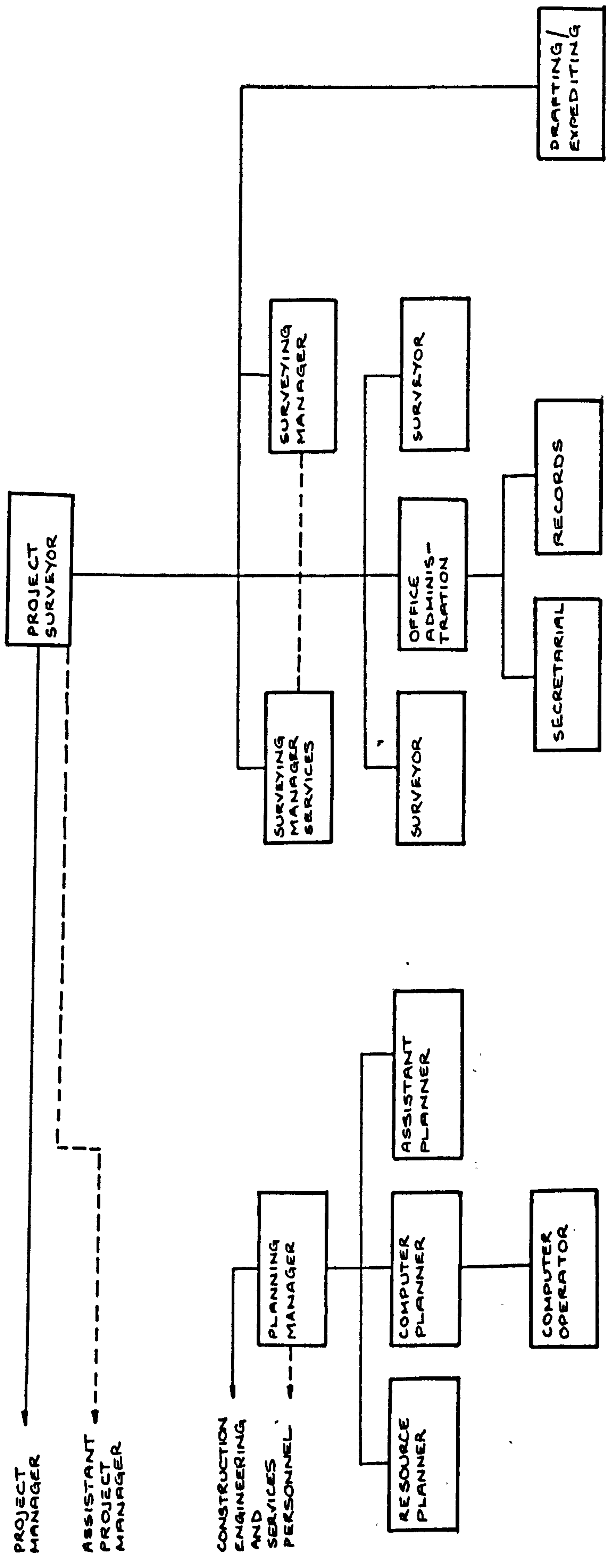
- Initiating all meetings appertaining to services and maintenance of communications with all parties in this respect.
- Assistance in the preparation of all tender documentation to ensure that appropriate and comprehensive bids are received.
- In association with the Planning Engineer and specialist sub-contractors ensuring that programmes are prepared for all services design, manufacture, fabrication, installation and commissioning works and that the programmes are monitored and updated as the progress of the work dictates.

Construction Manager

He was responsible for the following:

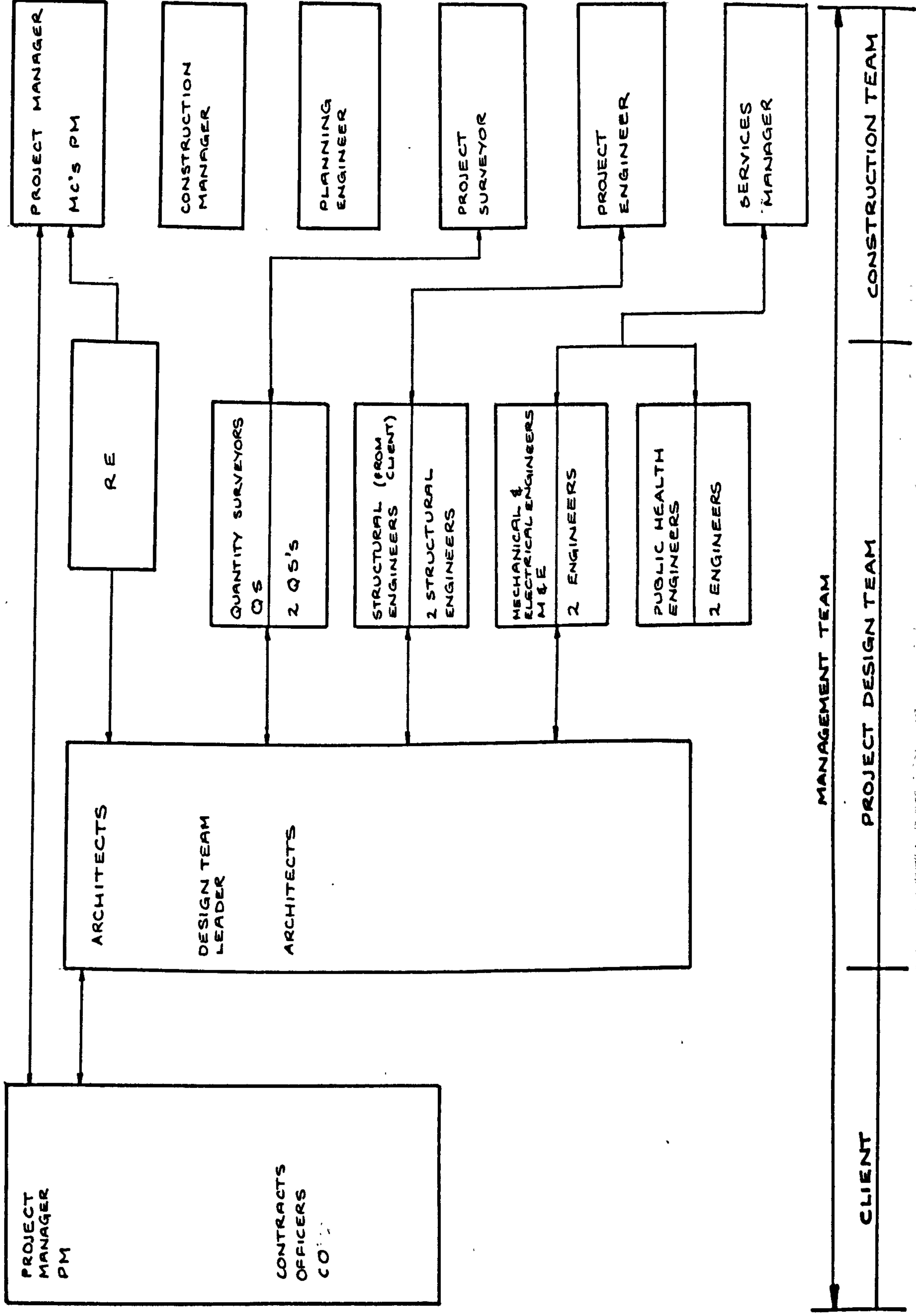
- Detailed production planning, site layout and organisation, safety and welfare.
- Organising and recording production meetings with the sub-contractors prior to their commencement on site to ensure the necessary planning, materials ordering and information flow is being maintained.
- Organising and recording site production meetings with all sub-contractors to check and record their work progress, to anticipate "bottlenecks" in site production and implement their resolution.
- Contributing to the general liason with the Project Team particularly in relation to the selection of practical construction techniques, diagnosis of defects and agreement of remedial work.
- The control and monitoring of sub-contractors progress prior to their commencing on site. He liased with the Design Team during this stage of information production.

MC'S SITE ORGANISATION



MT'S COMMUNICATIONS STRUCTURE

APPENDIX 5



DIVISION OF DECISION MAKING RESPONSIBILITIES

APPENDIX 6

ACTIVITY		PARTY INVOLVED	COMMENTS
<u>CONCEPTUAL PHASE & DESIGN</u>			
A	BRIEF	PM	
B	DESIGN	PM	PUT A BUILDING ON SITE ACCORDING TO BRIEF, IN TIME, AND WITHIN THE AGREED BUDGET
C	APPROVAL OF COST PLAN AND OVERALL CONSTRUCTION PERIOD	PM	
D	APPROVAL OF PROPOSED PRE-ORDERING AND PRE-PURCHASING OF MATERIALS	CO PM	THE CO TELLS THE PM THE PROCEDURE WHICH SHOULD BE FOLLOWED
E	<u>TENDERING OF SUB-CONTRACTS</u> (ALL SUB-CONTRACTS)	CO	IN ORDER TO MAKE SURE THAT ALL APPROVED BY CLIENT, SUB-CONTRACTORS ARE ALLOWED TO TENDER, ACCORDING TO REGULATIONS
		CO	
		PM	
<u>CONSTRUCTION</u>			
F	- CONTROL OF MC PERSONNEL	PM	<ul style="list-style-type: none">- SO APPROVES ONLY THE APPOINTMENT OF PERSONNEL OF THE SUB-CONTRACTORS- THE PM ALLOWS THE SO TO RUN THE PROJECT IN ORDER TO ACHIEVE THE AGREED TIME - COST - QUALITY TARGETS
G	APPROVAL OF EXTENSION OF TIME BEYOND PROGRAMME OF CONTRACT	SO	AUTHORITY DELEGATED TO HIM BY CO
	APPROVAL OF SUB-PROGRAMMES AND ADJUSTMENTS WITHIN THE CONTRACT PROGRAMME	PM	

(Cont.....)

(Cont.....)

<p>H</p> <p>APPROVAL OF DEPARTURES FROM THE COST LIMIT, EXCEPTING ONLY VARIATIONS OF PRICES (VOP)</p>	<p>PM</p>	<p>IT IS IMPORTANT THAT THE PM IS WARNED AT AN EARLY STAGE DURING THE YEAR, SO HE CAN PROPOSE THE REQUIRED ADJUSTMENT OF THE ANNUAL BUDGET ALLOCATED TO THE PROJECT BY THE CLIENT. (THE MONEY IS COMMITTED TO THE PROJECT DURING THE PREVIOUS FISCAL YEAR ON THE BASIS OF THE PM'S FORECAST)</p>
<p>I</p> <p>PAYMENT AGAINST INTERIM AND FINAL CERTIFICATES</p>	<p>PM</p>	<p>SO PREPARES INTERIM AND FINAL ACCOUNT, BASED ON ACCOUNTS PROVIDED BY MC FOR THE WORKS AND THE MANAGEMENT FEE</p>
<p>J</p> <p>DISPUTED CLAIMS</p>		<p>PROCEDURE FOLLOWED: QS VALUES THE CLAIMS SO INFORMS THE PM WHO AUTHORIZES HIM TO CERTIFY THE CLAIM</p>

Definitions of Schedules A, B, C, D and E

Schedule A covered all the pre-commencement services costs; ie wages or salaries, insurance contributions etc of all the persons engaged by the MC, on a full or part time basis in order to provide the pre-commencement services and the cost of any computer service the MC provided at rates agreed with the Client.

Schedule B covered the site management costs which briefly consisted of:

- All payments including salaries, wages etc paid to full or part time persons engaged on the site to carry out and complete the works.
- The cost of insurance against damage of the works and injury to persons.
- The cost of materials, permanent and temporary, plant and tools used in connection with work carried out by the MC's employees and not priced under Schedule C or covered by Schedule D.
- The costs for any computer services provided by the MC at rates agreed with the Client.

Schedule C covered lump sums quoted by the MC in his tender offer, for preliminaries; ie offices, rates, temporary accommodation for the MT, hoardings etc.

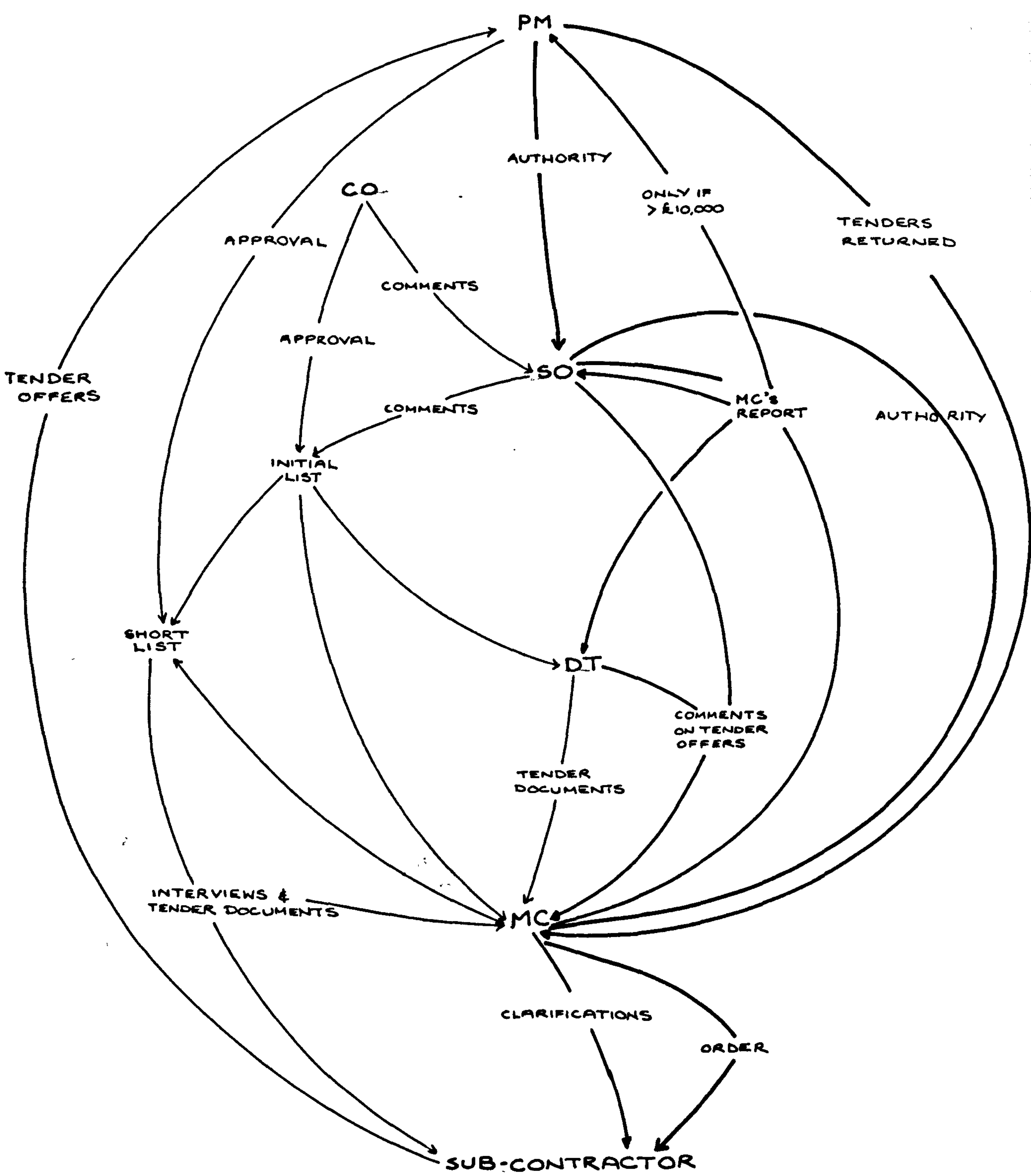
Schedule D defined the sub-contract cost which consisted of:

- Costs of materials for permanent and temporary works, and not included in Schedules B or C.
- Payments to suppliers and sub-contractors under the terms of the conditions of the sub-contracts.
- The cost of provision, including transportation etc, of mechanical plant and tools, workshops, any gantries over existing roads and fire

fighting equipment.

Schedule E covered the definition of management fee which is outlined in para 3.3.1.

TENDER PROCEDURE



- SELECTION
- APPRAISAL
- ORDER

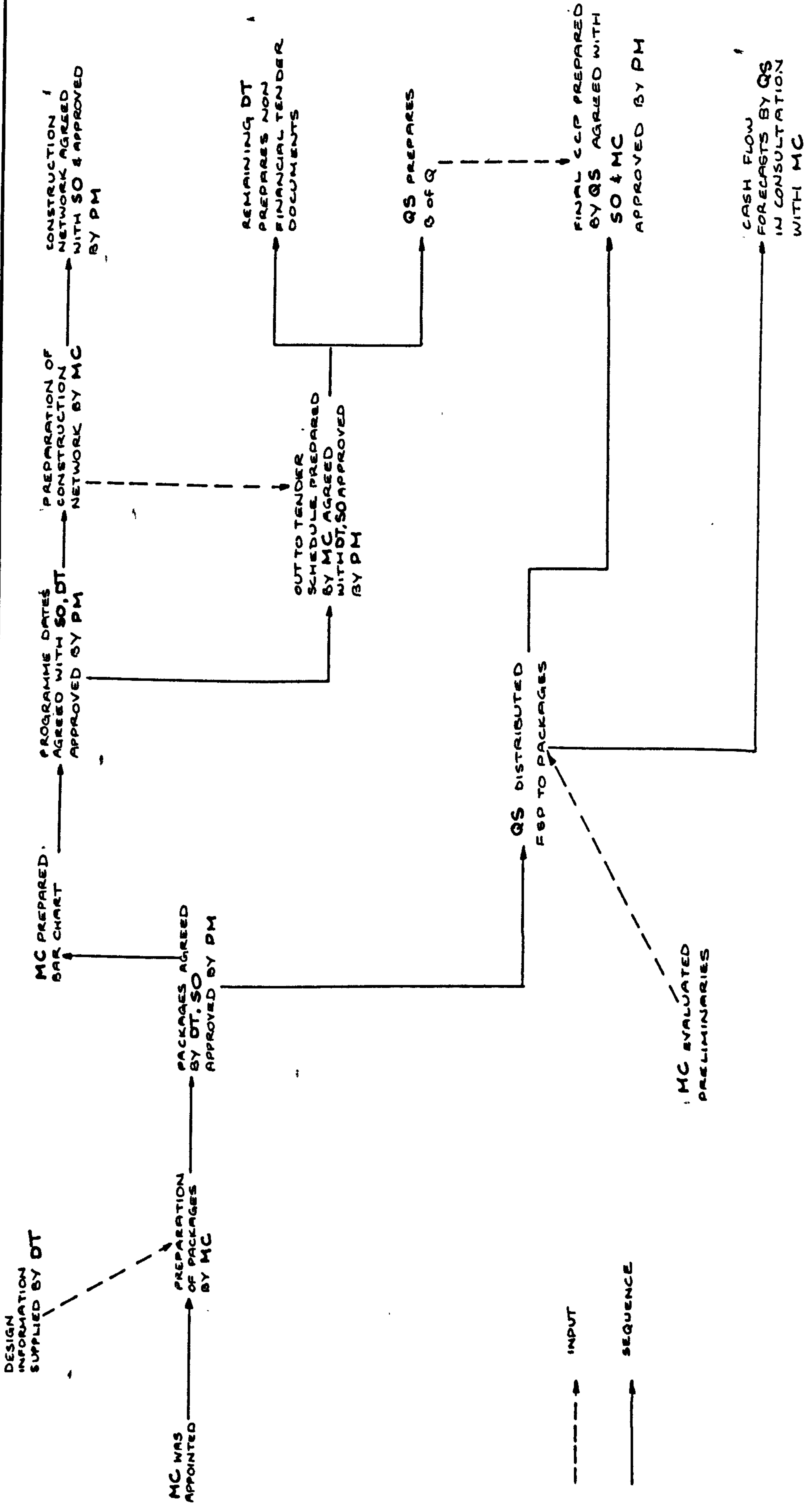
PREPARATION OF CCP, CONSTRUCTION PROGRAMME & OUT TO TENDER SCHEDULE

APPENDIX Q

APRIL, YEAR 0

PRE CONSTRUCTION PHASE

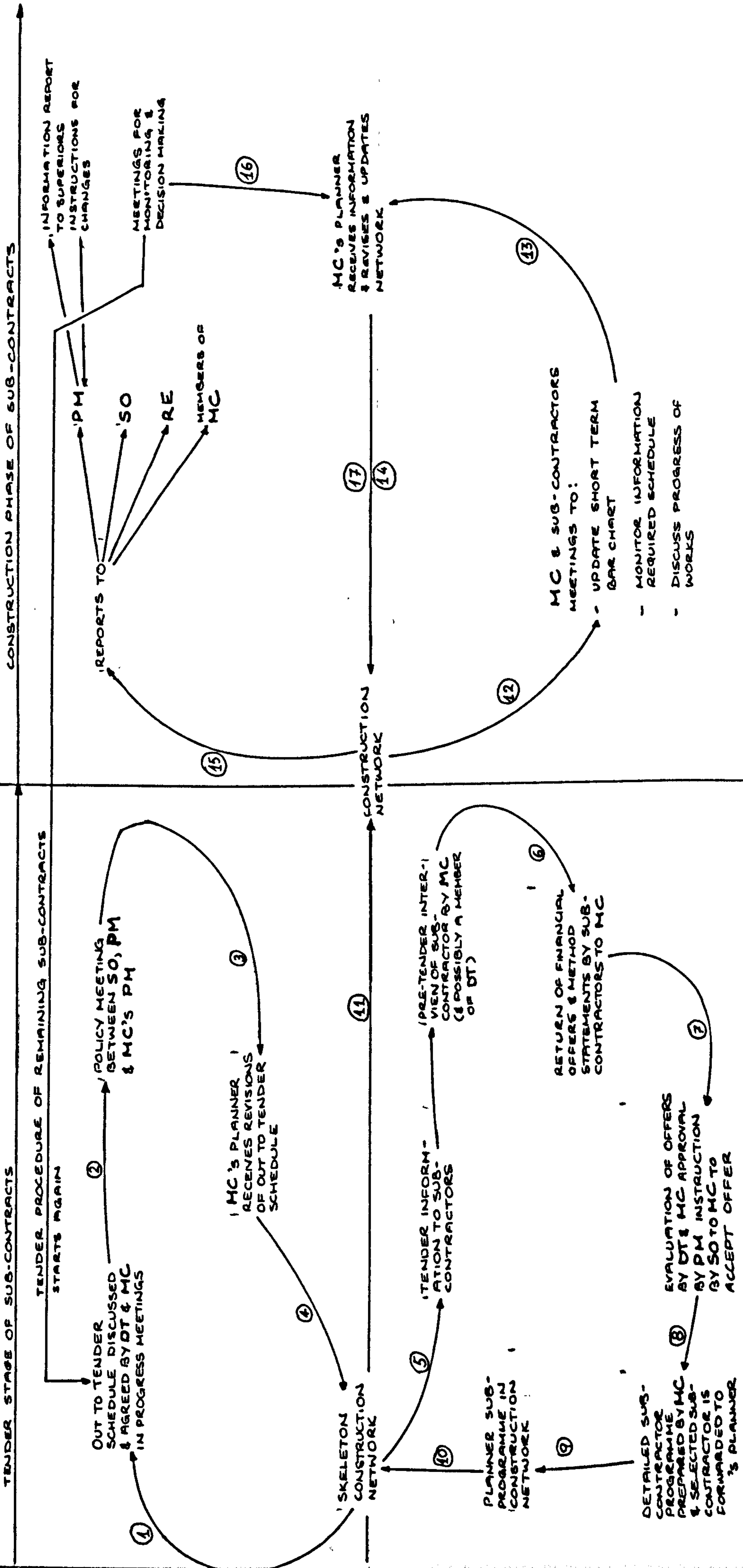
APRIL YEAR 1



TIME SCHEDULING AND CONTROL

APPENDIX 10

PROJECT'S CONSTRUCTION PHASE

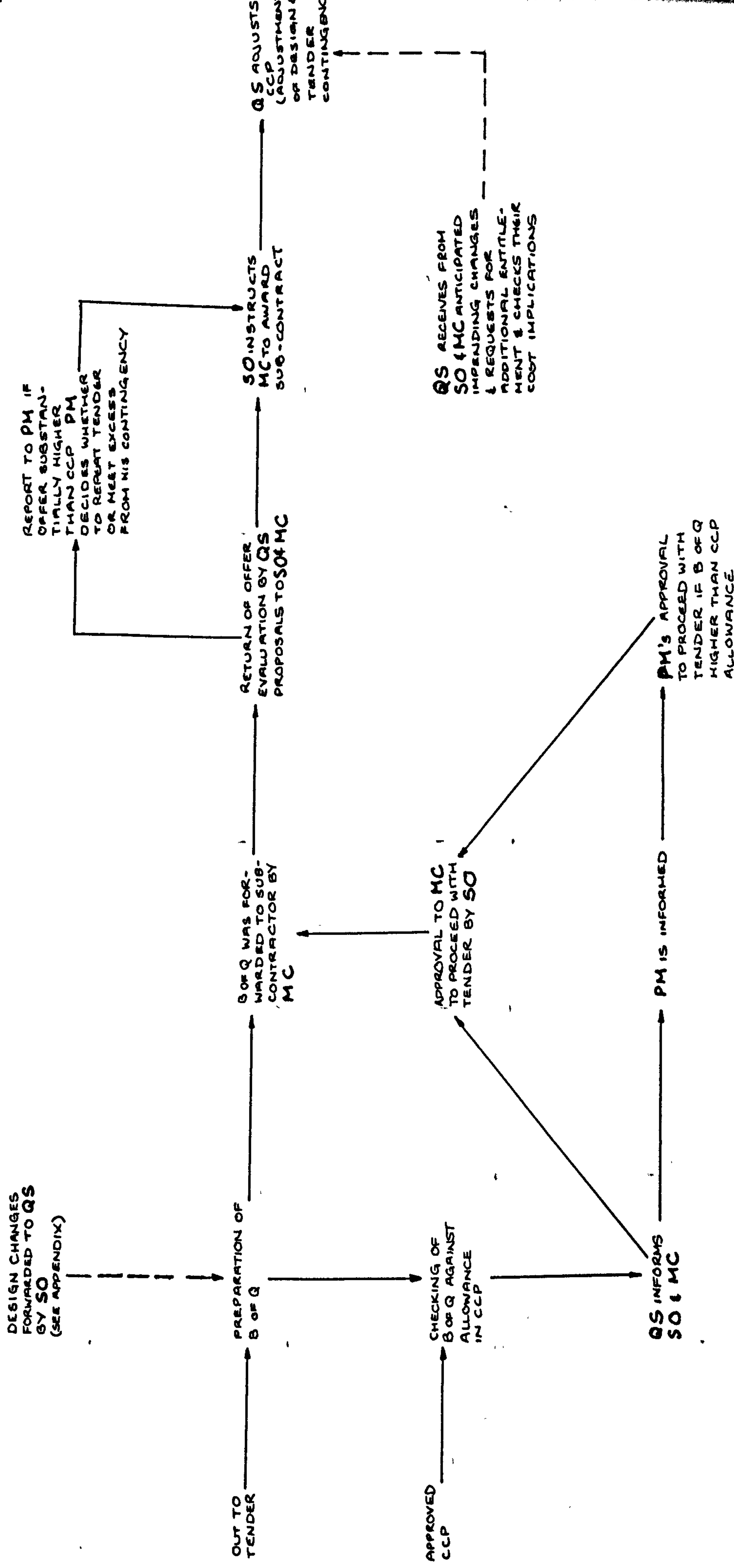


ADJUSTMENT OF CCP DURING A SUB-CONTRACTS TENDER STAGE

PROJECT'S CONSTRUCTION PHASE

TENDER STAGE OF A SUB-CONTRACT

CONT.



ADJUSTMENT OF CCP DURING A SUB-CONTRACTS CONSTRUCTION PHASE

SUB-CONTRACT'S CONSTRUCTION PHASE

REPORTS PRODUCED BY QS

1. MONTHLY COST REPORT
2. MONTHLY CASH FLOW ESTIMATE
3. QS'S FORMAL REPORT

(12) COST REVIEW MEETING QS & SO

(13) MEETING BETWEEN SO & PM ADJUSTMENT OF PM'S CONTINGENCY

(15) QUARTERLY MEETINGS OF MT

(16) CORRECTING ACTION

OUTPUT INFORMATION & DECISIONS

ADJUSTED CCP

(14) ADJUSTMENT OF SO'S CONTINGENCY

(10)

COPY FORWARDED TO QS

(3) COPY OF SUB-CONTRACT PACKAGE INSTRUCTIONS TO QS

QS'S EVALUATIONS

(4) a) ESTIMATED EVALUATION OF SO'S INSTRUCTION & ALLOCATION TO PACKAGES & APPROPRIATE CONTINGENCY

b) ESTIMATED CALCULATION OF CLAIMS

c) INTERIM & FINAL MEASUREMENTS, MONITORING OF DRYWORKS PC'S ETC

d) ANTICIPATED IMPENDING VO'S & REQUESTS FOR ADDITIONAL ENTITLEMENTS

(8) BIWEEKLY MEETING BETWEEN QS & MC

(7) MC INFORMS QS ON - VALID CLAIMS - SETTLEMENT OF CLAIMS

(9) MONITORING & CHECKING OF MC'S NET COSTS BY QS

EVALUATION & APPRAISAL OF MAJOR CHANGES BY QS & DT

(1) VO'S ISSUED BY SO TO MC

(2) MC INSTRUCTED RELEVANT SUB-CONTRACTORS

(5) SWO'S BY SO AT FORTNIGHTLY INTERVALS

CONTROL OF COSTS

INPUT INFORMATION

PROJECT F

The project was the erection of a new supermarket on a site located in a northern English town.

The Owner was an expanding retail limited company.

CONTENTS

List of Abbreviations Used

1. Nature of Project
2. Owner Client
3. Management Organisation
4. Contract Control System
5. Causes of delays and cost increases
6. Effectiveness of the Control System
7. Comments Conclusions and Improvements

ABBREVIATIONS USED

SPECIAL TO THIS REPORT

Client	Limited company owning a chain of supermarkets
BR	British Rail
LA	Local Authority
MT	Management Team
DT	Design Team
MC	Management Contractor
QS	Client's Quantity Surveyor
EPC	Estimated Prime Cost

Client's Personnel

MD	Managing Director
PM	Project Manager
PMR	Planning Manager
EM	Estates Manager

MC's Personnel

RD	Regional Director
DD	Divisional Director
MC's QS	MC's Quantity Surveyor
CM	Contract's Manager
Agent	Site Agent

STANDARD ABBREVIATIONS

C of C	Conditions of Contract
B of Q	Bill of Quantities
AI	Architect s Instructions
M and E	Mechanical and Electrical
PC	Prime Costs

PROGRAMME YEARS

Year 1	The MC was appointed in June
	The first contract was awarded in September
Year 2	The building was handed over to the Client on 3 May
	The parking area was handed over on 17 May

PROJECT F1. Nature of Project1.1 Purpose of the project

The new supermarket was built as a replacement to an existing town supermarket which was small and did not have adequate parking facilities for the customers.

The new supermarket was built on a site leased from British Rail (BR).

It was therefore hoped that the new supermarket would:

- Increase the trade for the Owner, since the new building had larger and better equipped sales, storage and processing areas, and better parking facilities for the customers.
- Free the existing building, owned by the Owner, which could be rented out and thus bring additional revenue to the Owner.

1.2 Technical description1.2.1 Site and building layout

The building was located at the West end of a rectangular site, shown in the sketch of appendix 1.

The South side of the site borders with a road with a 3m average elevation above the site.

Two ramps, one for cars and one for pedestrians, and a flight of steps, gave access to the site from across the road.

The railway line and the BR car park at the North and North West of the site were on the same level as the site.

The supermarket was a two storey building with a total area of 3,300 m².

Appendix 2 shows the layouts of the ground level.

The ground floor area, approximately 2,900 m² contained:

- the sales area, approximately 2,100 m²
- the process area, approximately 350 m²
- the storage area, approximately 450 m²
- the loading area at the back of the building was covered by a canopy.

The Upper Level consisted of two separate from each other units of approximately 400 m².

One of the units housed the administration offices and the second one the staff canteen and utility rooms and the H and V plant.

1.2.2 Brief specification of the works

1. Substructure. Reduce level excavation and disposal including nominal amount of imported fill.

Reinforced concrete ground beams spanning between RC pile caps driven in situ piles.

In situ reinforced concrete ground floor slab on hardcore sub-base with polythene damp proof membrane.

Warehouse slab with early age ground finish reinforced with two layers reinforcement on hardcore sub-base with polythene damp proof membrane. Brickwork below damp proof course to be in Class B Engineering Bricks.

2. Superstructure Frame. Structural steel framed building with in situ concrete and lightweight fire protection.

Precast concrete first floor slabs to offices and staff accommodation. Staircases internally in reinforced concrete with external fire escape in lightweight steel.

3. Roof Construction and Finishes. Flat roof constructed with galvanised steel decking with a prefinished enamel soffit to Sales Area fixed to structural steelwork covered with three layers built-up felt roofing including vapour barrier and insulation.

Galvanised pressed steel gutters.

Pitched roof to perimeters constructed of timber rafters, blockings, etc covered with 'Thrutone' asbestos cement slates on battens and underfelt and all necessary flashings and cappings.

4. External Wall. Main entrance wall including 8.00 returns at both ends to be cavity construction comprising Thermguard block inner skin, 50 mm cavity and reclaimed natural stone outer skin, bedded and pointed in plain mortar.

Remaining walls to be as above but with Forticrete Leicester Bathstone DCM outer skin, bedded and pointed in plain mortar with flush

horizontal and vertical contrasting bands of Forticrete DCM blocks.

External windows to be in polyester finished aluminium frames glazed with Antisun glass and bronze aluminium panels.

External doors to be external quality plywood faced solid core flush doors finished for painting.

Polyester finished aluminium entrance doors and screen.

Galvanised steel roller shutter door to goods delivery area.

5. Internal Partitions. Internal partitions to form various staff rooms etc in 100 mm/150 mm blockwork depending on height.

6. Internal Finishes.

Floor Finishes. Floor finish to Sales Area and Preparation Areas to be precast terazzo tiles. Toilets and Kitchen to have clay quarry tiles, Storage Area to be early grind concrete finish. Staff offices to be carpet tiles and all other areas generally to be vinyl tiles on sand and cement screed with softwood painted skirtings.

Ceiling Finishes. Underside of roof decking to be prefinished to Sales and self finished to Warehouse with exposed steelwork painted. Suspended ceilings to the staff areas, preparation rooms, toilets and

main entrance.

Wall Finishes. To be generally plastered and finished with emulsion paint, storage plant and sales areas to be fair faced blockwork finished with emulsion paint. Food preparation areas to have stainless steel linings. Glazed wall tiles to the Kitchen, Toilets, Entrance Foyer and Bakery.

7. Mechanical Installation. High level air heaters to the Sales Area, low pressure hot water heating system to all other areas, hot and cold water installations, sanitary fittings to Male and Female Toilets, refrigeration pipework and internal and external plumbing including rainwater downpipes.

8. Electrical Installation. (Lighting etc).

9. Client's Equipment. Kitchen equipment, refrigeration cases, alarms gondolas, check-outs, fire extinguishers, bakery equipment etc.

10. Drainage. Stoneware surface water and foul drains with concrete/shingle beds and surrounds including necessary manholes, gullies, sewer connection and petrol interceptor.

The surface water and sewer outlets were connected to the LA sewers by means of a 1,200 mm diameter drain tunnelled under the main Railway Line.

11. External Works.

Site Clearance. Remove existing fences, brick walls, etc, and reduce level excavations including disposal.

Service Yard. 200 mm in situ concrete bed reinforced with a single layer of reinforcement on 200 mm hardcore sub-base.

Roads. Road construction 150 mm thick. Bitumen Macadam laid on 300 mm DOT sub-base Type 1 edged with precast concrete kerbs.

Car Parking. 80 mm Bitumen Macadam laid on 200 mm bed granular fill including necessary concrete kerbs and white lining to form parking areas.

Pedestrian Areas. Precast concrete paving and brick pavements on 200 mm

bed of granular fill.

Service Yard Wall. 2.50 m high reinforced Forticrete block wall bedded and pointed in plain mortar including coping and in situ concrete strip foundation.

Boundary Fence. 1.80 m high plastic coated chain link fencing and angle posts.

Landscaping. Grading, levelling and imported top soil average 300 mm thick including a provisional allowance for trees, shrubs and small bushes.

Vehicle Access Ramp. Vehicle access ramp constructed in reinforced concrete including foundations, columns, beams, suspended slab, retaining walls, granular fill and reclaimed natural stone facing with metal balustrades.

Pedestrian Ramp etc. Pedestrian ramp, stairs and retaining wall constructed in reinforced concrete and faced with reclaimed natural stone.

Work to Springs Lane retaining wall. Provisional allowance for work to existing retaining wall and repairs/decorations to metal railings.

Culverting Stream. Culverting the stream and other existing drains which pass through the site area.

1.3 Time schedules

A Management Contractor (MC) was appointed in June of Year 1.

Construction was planned to take 8 months ie from 6 September of Year 1 to 17 April of Year 2.

The Owner had hoped that works would have commenced six months earlier but his application to the Local Authority (LA) for a land use planning permission was rejected. A public inquiry was held after the Owner

appealed to the Department of the Environment (DoE) and planning permission was awarded in the spring of Year 1.

The buildings' perspectives drawings were submitted to the LA in July of Year 1 and the planning permission for the building was awarded in August of Year 1.

The works described in paragraph 1.2 were allocated to 41 sub-contract packages.

The packages were designed in detail, tendered and built in a sequence determined by a time scheduled by the MC and agreed with the rest of the members of the Management Team (MT) ie the detailed design of the packages was overlapped with the project's construction phase.

The first package was tendered on 6 September of Year 1.

The building was handed over to the Client on 3 May of Year 2 ie two weeks later than the contract's completion date due to problems with the drainage (para. 5.1.1).

Works in the parking area were completed two weeks later ie on 18 May of Year 2. (Four weeks delay due to problems with drainage and inclement weather).

We observed the project during its construction phase.

1.4 Costs

In November of Year 0 the Board of Directors based on the Architect's and QS's cost estimate, budgeted £1.3m for the project.

This budget was revised to £1.783m in June of Year 1 for the reasons

explained in para. 2.3.

In November of Year 1, the Adjusted Estimated Prime Cost (EPC),
(explained in para 4.12) was produced by the QS.

The following table gives a summary of the costs quoted in the November
EPC:

	(in millions)
Construction cost of 38 packages	£ 1.448
Technical contingency	£ 0.060
Preliminaries	<u>£ 0.138</u>
Total	£ 1.646
MC's estimated fee (6½%)	£ 0.107
Less anticipated discounts	£ 0.030
Allowances for price increases	£ 0.060
(between November and time of tender of each package)	<u> </u>
Estimated total cost	£ 1.783

Some provisional sums had been included in the cost estimates of
individual packages eg for the purchase and installation of the crash
barriers of the car ramp, for excavation of soft rock etc.

The following information can be deduced from the revised EPC produced
at the end of April of Year 2. (This was the last revision):

	(in millions)
Construction cost estimate	£ 1.448
(as in 1 st EPC)	
Tendered value of 41 packages	£ 1.307
ie a 10% decrease	
Construction cost estimate in	
April Year 2	£ 1.507
ie a 15% increase of the tendered value	
Technical contingency	£ 0.060

The remaining data for preliminaries, price contingency and MC's fee had not been adjusted.

The final accounts were expected to be completed by the end of the summer of Year 2.

In May of Year 2, when I last visited the QS, due to a number of outstanding claims and extra works which had to be carried out in Spring (see para. 5.1.5), it was not certain whether the final cost would exceed the budget (£1.783m).

Thus, assuming that the final cost would not exceed the budget, the total cost increase in base prices was approximately 18%.

This increase was covered by:

- The 0.060m technical contingency
- The £0.140m balanced discount total offered by the sub-contractors
- A part of the £0.060m price contingency which was not used, due to lower price increases than anticipated in Autumn of Year 1.

2. Client

2.1 Client's nature

The Client and Owner was an expanding public company which owned a chain of supermarkets in the North of England and the Midlands. The Client had been building an average of two new supermarkets every year.

Because of the Client's continuous expansion:

- The number of his staff (Client's management organisation) involved with the implementation of the new projects, their role in the decision making and their inter relations were continuously evolving.
- The type of contracts awarded for the construction of projects was under continual review in the light of experience with previous projects.
- The project's management organisation (MO) changed as the types of contracts changed.

The Client's employees who were involved with the site acquisitions, designs and construction of new projects at the time of the project's implementation are shown in appendix 3.

There was no in-house engineering department because the design and supervision workload did not justify such a department.

For every new project a design team (DT) of professionals provided by private firms was set up.

The DT consisted of the following disciplines:

- Architect
- Quantity Surveyor (QS)
- Structural Engineer
- Mechanical and Electrical Engineers (M&E)

During the project's implementation the Client's philosophy was to involve only a small number of his employees with the decision making. Thus decisions could be discussed informally and be taken quickly, because they did not have to be filtered through a large number of departments before they were endorsed (as in the opinions of the PM and PMR happened with some of their larger competitors with more complex management structures and in-house engineering departments).

2.2 Duties of members of Client's staff

The Managing Director, MD, recommended to the Board of Directors the purchase of a new site and the budget which they had to reserve for the building's construction.

During the construction phase he was kept informed by the departments involved with the planning and construction, of progress against the programme, possible changes of costs etc. If an increase of the budget was necessary, it had to be approved by the Board.

The Estate Manager (EM) was answerable to the MD and his main objective was to find new sites. His involvement with the project ceased when the Client decided to purchase the site.

The Planning Manager (PMR) was directly answerable to the Retail and Sales Director. During the conceptual phase his duties were to:

- evaluate the commercial potential of the sites proposed by the EM
- to ensure that, given the limited total area of the proposed building each of the Client's sales departments was allocated a fair space area (preferably as close as possible to the space they had requested)
- to direct the Architect in the design of the layout arrangement, external appearances etc, so that the building was as functional as possible; it reflected the Client's image etc.

During the planning and construction phases, changes aiming at the improvement of the building's function were initiated by the PMR, but had to be approved by the MD.

The Project Manager (PM) was directly answerable to the MD.

The PM became involved with every new project when the Board approved the purchase of the site. Besides his involvement with the new buildings the PM was also in charge of the purchasing of equipment for the buildings the building maintenance and energy management.

His main duties during the construction phase of a new building were:

- liason between the Client and the professions of the MT eg Architect MC etc
- to ensure that the project was completed within the contractual time and budget, provided that no design changes were introduced, (initiated by the Client or in order to encounter unforeseen technical problems)
- to notify the MD of delays and overspending, and their causes.

The PM in his capacity could approve changes, mainly related to materials, provided that there were no major cost implications which would affect

the budget or the function of the building.

2.3 Procedures followed by the Client and MT during the conceptual and construction phases

A three member team, under the ME, was continuously searching for sites suitable for supermarket developments. It was possible that as many as 30 sites were under investigation at any time.

The project's site was first found in the spring of Year 0.

A firm of Architects who had been used by the Client for the design of one of his developments two years earlier, was asked to investigate whether a land use permission for the site would be awarded by the LA.

The Architect and the QS, using the revised for inflation unit costs of the earlier development, estimated that the total cost would be £1.30m.

It was the Client's policy that no costs were reimbursed to the Architect or QS at this stage. Their only incentive was that, should the Client decide to proceed with the development, he would feel morally obliged to appoint them to carry out the design. (Should the project fail to proceed, minimal reimbursement might be considered to pay for the time spent on the project).

A feasibility study carried out by the MD showed that the project was commercially feasible.

In November of Year 0 the Board approved the development and reserved the budget of £1.30m.

Following the Board's approval the PM became involved with the project

and the Architect was appointed on a percentage fee basis but not before planning permission had been granted (in accordance with RIBA regulations).

An application for a land use permission was submitted to the LA by the Architect but the permission was delayed, as it has been mentioned in para. 1.3.

When the permission was finally granted in spring of Year 1, the members of the DT were appointed by the Client and a contractor whom the Client had used on a cost plus fee basis was appointed as a Management Contractor (MC).

In late May of Year 1 the PMR prepared a provisional internal layout arrangement of the building. There was no standard layout of the buildings adopted by the Client because:

- the PMR in consultation with the sales departments were continuously revising the layout arrangements, especially in the sales area, in order to improve the building's functioning
- of the varying shapes of the sites which determined the location of the car park, the service area, the shape of the sales area, its entrances etc.

Based on the provisional layout the building's perimeter was defined and a number of alternative perspectives showing the side elevations of the building were prepared by the Architect.

In June of Year 1 the QS revised the total cost estimate, and the Board reluctantly increased the reserved budget to £1.79m because:

- it was realised that a larger building than had been assumed in the

previous estimate could be built. (The Client always developed the sites to their full capacity permitted by the LA).

- it was realised that expensive foundations would be required due to the depth of soil deposits on the site
- the QS had originally assumed that a conventional contract was going to be awarded, and in his opinion, the Management Contract was going to be costlier.
- it was realised that the site's drainage was going to be costlier .

2.4 Client's expectations

The way the Client weighed the inter-dependent variables, cost-time-performance, was determined by his interpretation of their implications to the project's purpose.

- a. Time. Building the project in the shortest possible time was important for the Client because of the loss of revenue when delays occurred. (In some projects where the opening date coincided with a high spending period eg Christmas, not meeting the opening date represented a substantial loss of revenue).
- It was also the Client's policy that a building was built and put into operation within one fiscal year. Thus, all the negative cash flows for the purchase of equipment etc, were registered in the first year, while during the second fiscal year a positive cash flow was registered due to the project s revenues.
- b. Performance. The Client's objectives were to build a building which:
 - was functional ie maximum utilization of the floor space area was achieved and the product display was arranged in such a way so as products were easily found by the customer
 - reflected the Client s image ie great variety of products at low prices. A building with a simple appearance was therefore what the Client expected the Architect to design

- would require low maintenance costs.
- c. Costs. It was important to the Client that the project's budget was as close as possible to the final cost and that high over-spending or underspending did not occur.

The MT was expected to try and cut costs wherever possible.

The Client was prepared however to increase the budget in order to meet the time schedule or improve the building's performance.

Over or underspending predictions as early as possible were important to the Client who could therefore find the additional money as early as possible or transfer the underspent funds to another project.

Thus the Client weighed the variables in the order of time-performance-cost.

2.5 Client's attitude

Members of the Client's organisation were actively involved with the architectural design and the monitoring of costs and time progress during construction. Their attitude reflected the weighing of the variables in the order stated in para. 2.4.

a. During the conceptual phase:

- In the production of the first layout the PMR placed more emphasis on the recommendations of the sales departments and his own personal experience with past projects than on the Architects objections to the proposed layout arrangements.
- The Architect was pressed by the the PMR and PM to produce elevations related to the Client's requirements. (Some of the first proposals were rejected as too extravagant and contrary to the Client's image).

b. Choice of the Management Contract. When the Client stepped up his expansion programme, four years prior to Year 1, the new buildings

were built under the conventional type of Architect and Contractor relationship. Two years later the relationship with the MC was formed. Buildings were at first built on a cost plus fee basis (ie it was up to the Contractor to decide which parts of the works he would carry out with his own workforce and which parts he would put out to tender) and later under a management contract (all works were put out to tender).

The Client favoured the Management Contract as opposed to conventional contracts because he believed that:

- under the open book cost system he was warned of over or under expenditures earlier,
- projects could be built more quickly because the design overlapped with construction
- there was more flexibility to request changes of design.

c. During the design the PMR initiated changes aiming at the improvement of the building's performance even if an additional cost was required.

The PM monitored the progress of the works and ensured that cost savings whenever possible were made.

He also initiated design changes which were likely to reduce the maintenance costs of the building provided that no serious cost implications were involved.

3. Project's Management Organisation (MO)

3.1 Management Team (MT)

The project's MT consisted of the PM, Design Team (DT) under the Architect's leadership, and the MC's members of staff.

In June of Year 1 all the members of the MT met for the first time away from their offices and the site in order to discuss the project, immediate problems, future meetings, etc.

The flow chart of appendix 4 shows the various members of the project's MT during the construction phase. The thick lines indicate the official lines of communication among the various members; the broken lines indicate the consultative links between some of the members. The structure of the DT has been mentioned in para. 2.1.

The MC's staff involved with the project were:

- The Regional Director (RD). He was in charge of the projects undertaken by the MC, within the geographical region which contained the area where the project was located. The MC's regional HQ were approximately 100 miles away from the project.
- The Divisional Director (DD) who was directly answerable to the RD. The DD was also based in the regional HQ and was in charge of all the projects the MC built within a part of the RD's region. Both the RD and DD visited the project once every month when they inspected the progress of the works and met with the MT.
- The MC's Quantity Surveyor (MC's QS) who was based in the regional HQ and was directly answerable to the RD.

- The Contracts Manager (CM). He was based in the regional HQ and was assigned to the Client's projects irrespective of where these projects were located. Every week he spent two days on site.
- The Agent was located on site and was in charge of the MC's site staff which fluctuated between three and five people. The Agent had been moved to this project from another of the Client's projects which had been completed in September of Year 1.

3.2 Delegation of authority and duties of the members of the MT

None of the DT's members had worked with a MC before. The duties of each member of the DT were not officially explained to them by the MC (eg in writing or during their first meeting).

Members of the DT thought however that they knew what their duties under a Management Contract were.

A summary of the intended role of each one of the MT's members during the various phases of the project's implementations, as those were presented in one of the MC's public relations leaflets, appear in appendix 5.

Our impressions of the intended duties of each member of the MT during the construction phase (except the PM and PMR whose duties were explained in para. 2.2) are outlined below:

- a. Under the Management Contract the Architect carried out a number of duties similar to those under a conventional project. Thus he had to:
 - issue Architects Instructions to the MC for clarification of design items or for design changes, irrespective of the nature of the works involved (eg Instructions for M and E works were issued by the Architect)

- apply and pursue them to LA departments or other public departments for planning permission for various external architectural features (eg illuminated signs)
- sign the interim and final payments and completion certificates
- forward to the DT requests made by the Client (PMR) for design changes, so that they could be evaluated or the design could be revised
- carry out quality control of architectural finishes, materials used, of workmanship etc
- issue instructions for design improvements provided that he did not exceed the technical contingency of £60,000 mentioned in para. 1.4.

In addition to the above duties, the Architect had to:

- evaluate the offers of sub-contractors, with the QS and MC
 - ensure that a large number of specification, technical drawings and other tender documents for each sub-contract were ready on time so that delays to the MC's construction programme did not occur.
 - ensure that all members of the MT, including the PM, were aware of design changes requested and agreed with the Client (PMR)
- b. The Structural Engineer's duty was to carry out the structural design of the building's structural elements and to ensure that the building was built according to the design and building regulations (eg check cube test result, method of pouring of concrete, curing etc)
- c. The M and E was also responsible for the M and E fittings during construction.

He was also responsible for the applications to various Authorities for the services connections ie gas, telephone etc.

Throughout the construction phase both the M and E and Structural Engineers also had:

- to produce design details, drawings etc
- to forward design clarification to the Architect so he could issue an Architects Instruction to the MC
- to evaluate and redesign parts of the design when technical problems were encountered or the Client requested design changes
- participate in the MT's meetings

d. The QS's main functions were to:

- prepare B of Qs for each package and derive the EPC (see para 4.1.)
- monitor cost and revise the EPC as packages were tendered and work progressed
- advise the MT on costs of alternative solutions to technical problems or design changes requested by the Client
- estimate the cost implications of instructions after they had been issued by the Client
- prepare interim and final valuations of the works
- evaluate and negotiate claims submitted by the sub-contractors to the MC

In order to fulfil his duties the QS worked in close cooperation with the MC's QS.

e. The MCs duty was to recommend the scope of the sub-contract packages, prepare the construction programme and then ensure that the programme was implemented.

In order to fulfil his duty he tried to:

- programme, control and coordinate the flow of design information from the DT to the MC and the Client to the DT, before and after the tendering of packages
- ensure that design information requested by the sub-contractors was forwarded to the DT and that the DT responded quickly
- manage the site resources ie coordinate the sub-contractors and monitor and control their performance

From the MC's staff the CM was responsible for the planning and monitoring of the contractual programme. Thus the CM was responsible for the preparation and revision of the construction programme, the flow of design information from the DT to the MC, the preparation of tender lists, evaluation of tender offers, the MC's reports to the MT and the coordination and guidance of the appointed sub-contractors.

The MC's QS was responsible for the planning of costs, in cooperation with the QS, and the monitoring of costs as the works progressed. The Agent was responsible for the day to day technical supervision of the sub-contractors, and his objective was to ensure that the weekly progress targets programmed by the CM were achieved. The RD and DD were more concerned with policy matters. They were kept informed of the progress of the works and ensured that action was taken when problems likely to delay the progress of the works occurred eg delay of issuing design information.

3.3 Types of contracts

3.3.1 Management Contract

The Contract was signed between the Client's MD and the MC.

Under the C of C the MC was reimbursed his site costs (salaries of site staff, preliminaries) on accounts approved by the QS and was paid a 6.5% of the project's Adjusted EPC (produced in November of Year 1) as a fee for his general overheads and profit.

By the time the EPC was produced the works of major risk items were well advanced and their cost estimates were therefore close to the expected final costs.

The Client believed that by relating the DT's and MC's fees to the

Adjusted EPC, they had an incentive to seek cost savings where possible.

A penalty clause had been included in the C of C for delays to the programme but the MC could balance it, if it was ever invoked by the Architect, by transferring the penalty on the sub-contractors who caused the delay. The MC would have to meet the cost of the penalty himself however if delays had occurred as a result of errors attributed to the MC's management.

The MC's incentives to finish the job within the contractual time were not due to the C of C but because:

- he had a financial interest to complete the job as quickly as possible
- he wanted to keep the Client happy and thus continue their relationship
- he did not want to damage his professional reputation

3.3.2 Sub-contractor's contracts

The sub-contractors C of C's were prepared and signed by the MC ie the sub-contractors were employed by the MC.

The types of the awarded sub-contracts can be grouped into three categories

- Fixed price contracts ie no price adjustment formula, because of the short life-span of all contracts and no measurement of the works awarded after competitive tendering among a selected number of sub-contractors.

There was a small number of packages however for which the works were admeasured due to the diversions from the tendered design.

- Design and construct. Such examples are the construction of the flat roof and the aluminium frames of the doors and windows. The Architect prepared the drawings and performance specifications and the sub-contractor produced the design details and manufactured and installed the parts.
- Negotiated sub-contracts. For example when it was decided to build the drainage tunnel, see para. 5.1.2, the MT decided not to tender the works as an independent sub-contract. In order to save time they authorised the MC and the QS to negotiate rates for the tunnel works with the sub-contractor who had already been awarded the package for the substructure and drainage.

The MC's main problem with the management of sub-contractors was that he had to control the resources (ie labour etc) of another firm. The means he used in order to persuade the sub-contractors to meet their time schedules were:

- stiff penalty clauses in their C of C
- to black-list them from future jobs the MC was involved with in any part of the country
- rigorous checks of the sub-contractors previous performance when the selection lists were set up

The tendering procedure was as follows:

- The MC prepared a list of 6 sub-contractors from the records kept in his HQ. Sub-contractors in the records had been checked for reliability on previous jobs, and for financial status.
- The MT commented on the list, and in some cases added or submitted sub-contractors to or off the list.
- The MC checked their willingness to participate in the tender, their current work load etc.

1. - Tender documents were handed to sub-contractors.

- The sub-contractors' offers were returned to the QS and were discussed by the MT in yhr policy or design meetings. (See para 3.1.2)

A decision to award the contract to the lowest tenderer was taken during the meeting or the MC was asked to clarify questions from MT members before the decision to award the contract was made.

4. Contract Control System

4.1 Planning

In June of Year 1 the CM prepared a provisional list of sub-contractors packages. In defining the packages the CM used his experience with previous projects and his main objectives were:

- to include homogeneous and sequential works with each package eg works of the same trade
- to have packages which were commercially interesting and thus sub-contractors would tender

The provisional list was presented to the QS and the MC's QS in order to proceed with the preparation of the EPC.

The CM proceeded with the preparation of the time schedule (bar Chart), the preparation of the out-to-tender programme (sub-contractors and suppliers reconciliation sheet), and the finalization of the sub-contract packages.

4.1.1 Time planning

- a. Bar Chart. By the end of September of Year 1 the CM prepared a bar chart which consisted of 25 activities programmed to be completed within the 8 month contractual duration mentioned in para. 1.3.

The CM prepared the bar chart based on his experience with previous projects the MC had built for the Client.

There was no fencing of activities, and their sequence, float and the activities critical to the contractual programme could be identified by the CM based on experience.

The bar chart was not updated during construction to account for the

actual time schedule. (See para. 1.3)

b. Reconciliation sheet of the sub-contractors and suppliers. The objective of the reconciliation sheet was to:

- i) guide and coordinate the parties involved during each package tender cycle
- ii) be used as a record of whether the target dates in the reconciliation sheet had been achieved and which sub-contractor had been awarded each package.

The CM prepared, early in the summer of Year 1, the pre-tender dates by which each member of the DT had to produce tender documents for each package, if the dates in the bar chart were to be achieved. The reconciliation sheet contained the following data which fulfilled objective 1:

- Title of package
- Date by which the MT had to approve the list of selected sub-contractors
- Date by which members of the DT had to supply design information to the QS
- Date by which the MC had to receive the tender document so he could go out to tender
- Date by which the tenders had to be submitted
- Date by which the MC had to receive the Architects Instruction to place the sub-contract
- Date by which the MC had to place the order with the sub-contractor
- Date by which the sub-contractor would start on the site
- Date of sub-contract's completion
- Name of selected sub-contractor

As the works proceeded next to each of the above dates the actual date was quoted and thus objective 11 was fulfilled.

4.1.2 Cost planning

The QS's cost estimate of June, Year 1 (para. 1.4) was based on approximate quantities of the building's sketch plan. Although the site investigation had not commenced yet, the QS was aware that pile foundations would be required, and thus he made provisions for a relatively large foundation cost.

The MC's QS derived his own cost estimate independently of the QS. Both estimates were discussed in a MT meeting before a proposal for the increase of the budget was made to the Client.

Following the appraisal of the budget increase the MT agreed that the QS would produce the adjusted EPC by September of Year 1. (It was however produced in November as mentioned in para 1.4).

The EPC contained:

- an analysis of the total cost allocated to the 41 packages, the contingency sums, the MC's fee, and the cost of preliminaries (see para 1.4)
- which item had not been included in the calculations eg items ordered by the Client, professional fees etc
- a brief description of the works and quality specifications of some items.

The estimation of the six main packages, corresponding to 60% of the project's value, in the first EPC were derived from B of Q's which the QS had produced in the summer in accordance with the reconciliation sheet. The costs of the remaining packages were based on the calculations for the June estimate.

The EPC was updated on a monthly basis to adjust the quoted costs of the

packages and of the technical contingency in accordance with:

- i) the B of Q's produced by the QS within the past month
- ii) the tender offers of the awarded packages
- iii) the cost adjustments of the packages under construction

Appendix 6 shows how the planning, monitoring and control of progress against the contractual programme, and expenditure against budget, were carried out by the members of the MT in the tender and construction phases of each package.

Steps 1 to 5 illustrate the adjustments of the EPC due to 1 and 11 mentioned above.

4.2 Monitoring and control

4.2.1 Input information

- a. Progress. The CM met the sub-contractors' Agents (step 6) every week in order to discuss:
- the design information they required from the DT for the following month
 - progress of the works against the sub-contractor's programme, and measures when slip-ups occurred
 - remedial works requested by the DT
 - problems which could affect the progress of the works.

The CM forwarded the requested design information to the DT and checked progress against the programme.

The Architects Instructions, or verbal instructions issued by the DT (see para. 4.3.2) were verified, and their effects were discussed during the design meetings held between the DT and MC.

A pink slip was issued by the CM to the members of the DT indicating

the member who had issued the instruction and the packages which were affected.

b. Expenditure. The cost estimate of each package in the EPC was adjusted (para. 4.1.2.111) by the QS in consultation with the MC's QS based on the following information:

- The interim and final payments to the sub-contractors based on the evaluation of the works carried out independently by the QS and the MC's QS
- The evaluation of the cost effects of the AI's written instructions (and the DT's verbal instructions) registered in the pink slips
- The evaluation of claims submitted by the sub-contractors. As in the case of conventional contracts the sub-contractor notified the QS of a claim through the MC's QS as soon as it was apparent, and submitted detailed accounts within reasonable time after the works were completed. Claims were negotiated between the sub-contractor and the QS and were settled by the Architect. During the negotiation the MC's QS expressed his independent professional opinion. If the sub-contractor disagreed with the Architect's proposal he could go to arbitration.

4.2.2 Output information

Each member of the MT reported to the rest of the team during the policy meeting step 12. (The policy meeting is described in para. 4.3.1).

The CM presented a written report and produced minutes of the meeting a few days later. The remaining members of the team reported verbally on outstanding points contained in the minutes of the previous meeting.

a. The Architect's report. The Architect reported on:

- Problems he had encountered in the design of the remaining

packages

- Progress made in obtaining planning permissions from LA or design agreement with BR
- Remedial works he requested

The purpose of the report was to inform the rest of the MT on design progress and in some instances to obtain their opinions of problems which had been encountered since the last design meeting.

- b. The Structural Engineer's report. He also reported in relation to the progress of design, his coordination with the LA's building regulation department and remedial work he thought necessary.
- c. M and E's report. The M and E informed the rest of the team on the progress of the design and on the progress he had made with applications to the gas, electricity and water boards.
- d. Client's report. The PM reported on decisions taken by the Client for design changes or on the progress of ordering items supplied directly by the Client (para. 1.4).
- e. MC's report. The object of the report was threefold:
 - i) To inform the members of the MT of the so far progress, and the progress planned for the following month.
 - ii) To inform the MT of the information required if the remaining packages were to be tendered on time.
 - iii) To give the DT and PM the design information or the decisions they had to take, so that the progress of the works is not delayed.

The report was based on a standard format the MC used on all the projects he managed. A detailed account of the report appears in appendix 8.

4.3 Control and decision making

4.3.1 Client's and MT's meetings

4.3.1.1 Client's meetings

- a. Planning meeting. This meeting took place every month. Among the participants were the MD, the Retail Director, Buying Director the PMR and the PM.

The design layout drawings were presented by the PMR and approved by the participants.

During the construction a number of design changes first discussed at this meeting, and the participants agreed whether they should be implemented.

The PMR suggested design changes and the PM, based on his knowledge of the progress of the works was expected to say whether such changes would have serious time or cost effects (without qualifying them).

- b. Client's design meeting. The PMR, the PM and the Architect met on a monthly basis in order to discuss architectural features etc. Changes aimed at improving maintenance standards were usually raised by the PM and discussed and decided at this meeting.
- c. The PM reported to the MD at regular intervals on committed costs and final cost forecasts in relation to the budget.

4.3.1.2 MT's meetings

- a. Policy meeting. Monthly meeting of the MT on site, the purpose of which was to:

- allow each discipline to inform the rest of the MT members their so far progress with the implementation of their duties
- coordinate all the disciplines of the MT, by giving them a chance to review the plans of the works to the next meeting and thus become aware of the information they had to supply, to whom,

when, etc, and decide the awarding of sub-contracts

- give a chance to members of the MT to bring the attention of remaining members to problems and seek solutions.

In the summer of Year 1 when the packages and the reconciliation sheets were being decided, these meetings were bi-weekly.

The reports outlined in para 4.2.2 were discussed during these meetings.

- b. Design meetings between the DT and MC. This monthly meeting took place two weeks after every policy meeting.

Design details (verifications), instructions issued, and technical problems were also discussed at this meeting.

Decisions for the award of sub-contracts based on tenders received since the last policy meeting were also taken.

4.3.2 Control of design changes

Step 13 of appendix 6 shows how the design changes were being filtered through the DT and MC and their evaluation was carried out.

Appendix 7 gives a detailed account of the procedures through which changes initiated by the Client, DT and MC were approved and valued.

- a. Changes initiated by the Client.

- i) During the Client's meetings the PMR would request (1) the Architect to examine design changes likely to improve the project's functioning.

The Architect would examine the possible methods and consequences with the appropriate members of the DT and MC and would then report to the PMR and/or PM (2&3).

Major changes had to be discussed and approved during the planning meeting before they were initiated by the PM (5).

- ii) The PM usually initiated changes likely to decrease the maintenance costs of the building (6). Depending on their cost effects the PM informed the PMR usually during the Client's design meeting in retrospect or before an AI had been issued.
- b. Changes initiated by the MC (8). Such changes were initiated by the MC in order to:
- accelerate the progress of the works
 - transfer some works from one sub-contract to another
 - encounter technical problems (para 5.1.2)

Such proposals were evaluated by the DT and their solutions were approved by the PM during the policy meetings before an AI was issued to the MC.

5. Causes of Delays and Cost Increases

A number of typical problems, encountered during the project's construction phase, and their cost and time implications are described in para. 5.1

The causes of these problems are summarized in para. 5.2 under six headings.

5.1 Examples of typical problems

5.1.1 Client's involvement

- a. Rearrangement of refrigerators in the sale area initiated by the PMR in a planning meeting.

When the AI was issued the floor slab, with the permanent ducts etc, had been completed. The QS estimated that the cost increase due to this design change was £5,000.

- b. Cash office. The Client delayed a decision for the exact location and dimensions of the cash office.

When the decision was finally made, in February, plant could not be moved to the area and the room had to be built by hand. The QS estimated that the additional cost due to this method of construction was £10,000.

- c. Illuminated signs. The shape and exact location of the illuminated signs on the facade of the building and car park was a subject which was discussed from the very early policy meetings, but a decision by the Client (MD) was made as late as March.

The Architect was anxious that the Client should approve his proposed signs as soon as possible because of the time required for the following Authorities to approve them:

- LA

- BR (ensure that train drivers were not blinded)

- Civic Society

The MC was also anxious because of the interference a late decision could have had on preceeding sub-contractors eg location and shape of supporting brackets had to be decided while the roof and walls were being constructed because of the required reinforcement.

5.1.2 Drainage

5.1.2.1 Description of problem

The drainage of the site and the building s sub-structure, excluding pilling, were included in one package (no 2).

The package was completed with a fourteen week delay which caused the time overrun of the project's construction programme mentioned in para. 1.3.

The delay was due to the following reasons:

- a. Two weeks' delay in the commencement of the works because of late information by the DT.
- b. One week delay pending decision on culverts under preparation area and warehouse, which closed with drains.
- c. Two weeks because of inclement weather.
- d. Nine weeks because of late design information and strain on the sub-contractors resources due to additional works (tunnel) required for the drainage of the rain water from the car park.

The DT examined, at first, the possibility of draining the rain water through the existing culvert, shown in appendix 1, which crossed the site.

The LA refused permission however, because it feared that the additional water flowing through a steep drop immediately after the railway line, (the flow of the water accelerated out of control due to the steep drop) would flood the lower areas downstream from the culvert.

A camera which was run by the DT, through the culvert's section under the railway line, also showed that this section was in need of extensive repairs.

Two alternative solutions were proposed by the Architect and Structural Engineer and were evaluated by the QS:

- To pump the water from the car park into the main sewerage pipes of the main road
- To control the flow by conveying the water through a tunnel (running parallel to the culvert) and a closed conduit down the drop before it was discharged into the culvert.

The DT recommended, and the MD approved the solution of the tunnel as the most feasible one. The MC negotiated the work with the already appointed sub-contractor of package 2 for £35,000, which was met by the Client (and not by the £60,000 contingency).

The delays in the supply of design information were caused because of the following reasons:

- i) The first design produced by the DT (a specialist engineering consultant was employed) was not approved by the LA. The DT was therefore obliged to redesign the tunnel in accordance with the LA's requirements

- ii) The DT's workload was increased considerably
- iii) Some aspects of the design had to be altered when a drain was encountered during tunnelling.

5.1.2.2 Implications of the delays of sub-contractor no 2

The above delays affected the progress of subsequent sub-contractors.

Two such examples were the following:

- a. External works sub-contractor (package no 4) which included the formation and surfacing of the car park, the construction of the pedestrian and car ramps etc.

Sub-contractor no 4 was delayed by 4 weeks, mainly due to interference (late commencement, having to work in the same area with another contractor etc) from contractor no 2 which had not been anticipated at the tender stage. If the amount of the additional car park drainage was known when the CM defined the packages, they would have been included in package no 4.

Sub-contractor no 4 claimed the sum of £30,000 as compensation for those delays (mainly due to increased site overheads). The amount claimed was not accepted by the QS because, in his opinion, the submitted accounts were incomplete and the costs grossly exaggerated.

(The claim had not been settled by May of Year 2).

- b. The erection of the roof had to be delayed until the site drainage was completed, otherwise the rain water from the roof would have flooded the site, and thus delay packages 2 and 4 even further.

5.1.3 Pedestrian ramp

When the sub-contractors for package 4 were invited to tender (end of September) the exact position of the boundary line with the road was not known.

The sub-contractor later claimed that his tender had been based on the assumption that for the construction of the ramp no temporary support of the road would be required. When the boundary line was defined it was realised that the line was closer to the building than it had been assumed during tender and that sheet piles had to be used.

The Architect and QS rejected the sub-contractor's £20,000 claim because in their opinion all temporary works are the sub-contractor's responsibility.

An ex gratia payment of £8,000 was offered by the Architect but it was rejected by the sub-contractor, who decided to refer the claim to arbitration.

The commencement of the works was delayed by six weeks due to agreeing of temporary works and congestion in the building's entrance area.

5.1.4 Car ramp

The construction of the ramp commenced three weeks late due to a late appointment because of a delay in the supply of reinforcement details by the Structural Engineer.

The progress was further delayed by:

- two weeks due to inclement weather
- one week because of the sub-contractor's low productivity
- four weeks due to remedial works ordered by the Architect and Structural Engineer and late delivery of the barriers

The car ramp was not critical to the construction programme, but the MC

was anxious to complete it because:

- The Client had an agreement with BR to gain access to the site by the beginning of Year 2 and thus stop gaining access through the BR car park. (Although the BR car park was used for access throughout the project's construction, BR did not cause any problems for the Client).
- The MC had programmed its construction for autumn in order to spread his supervision work load more uniformly.

5.1.5 High underground water table under the access road to the loading area

As a result of rainfalls in Spring of Year 2, soft spots appeared in the road's sub-base which, if they were not treated before the road was surfaced, could cause settlements.

The Structural Engineer examined some alternative solutions (eg the provision of a number of inter connected relief walls between the road and the railway line).

The DT and MC decided however that in order not to delay the works any further the soft material should be excavated and the potholes (a few metres deep) should be filled with coarse material.

The additional work (excavation) was expected to increase the final cost of package 4 but the exact increase had not been calculated in May of Year 2 (para. 1.4).

5.1.6 Remedial works and interpretation of design specifications

- a. Stainless steel cladding in the meat preparation area. When the metal sheets were delivered on site they were found to be defective,

the Architect carried out a random check of the delivered batches, and the sub-contractor was instructed to return them to the manufacturer. Thus a delay of two weeks was caused and the MC had to press the sub-contractor to increase his workforce in order to make up for the delay.

The cladding was also delayed by three weeks, due to preceeding trades.

- b. Boiler room plant. The sub-contractor's detailed drawings, supply and installation, had to be drafted three times until the M and E was satisfied that the product would comply with his specifications.

5.1.7 Late instructions

- a. The progress of the structural steelwork (package 5) was delayed by a week because of late information by the Structural Engineer. The unloading bay canopy was delayed by five weeks due to detail changes by the Structural Engineer from assumed steel columns to reinforced concrete columns.
- b. A number of design changes, mainly of design specifications was also initiated by the Architect.

5.1.8 Delays due to the sub-contractors

- a. Piling (package no 3). The cost of the sub-contract was increased by £5,000 due to an increase in the number of piles from 145 in the bill to 158. (The length of the piles was also greater than the assumed length in the bill).

The commencement of the works was delayed by a week due to the late arrival of the pile rig.
- b. Flat roof (package no 6). The package was completed 9½ weeks late to programme, because:

- The commencement of the works was delayed by 2 weeks while awaiting delivery of decking due to a late order, by the MC to the sub-contractor
 - A further week was lost while the sub-contractor organised his labour force
 - 2½ weeks were lost due to inclement weather
 - Gutter delayed while awaiting delivery of polystyrene
 - A further week was lost on gutters and waiting for sheets for the office roof
- c. Pitched roof (package no 4). The progress was delayed by 5½ weeks (against the sub-contractor's programme).
- The works commenced a week late to programme until timber was delivered
 - 3 weeks delay while waiting for completion of gutters by flat roof contractors
 - 1½ weeks lost due to inclement weather

5.2 Nature of problems and implications

It can be concluded from the examples of para. 5.1 that the problems which were encountered during the project's construction phase had the following consequences:

- some critical activities were delayed and thus the MC was awarded, by the Architect, an extension of the contractual period (see para 1.3)
- as the non critical activities became critical, the DT's workload peaked unexpectedly, thus putting additional pressure on their resources, and diminished the DT's profit margins
- the additional works and claims increased the cost estimate and made the forecasting of the final cost difficult (see para. 1.4)

The causes of those problems were due to the Client's expectations, project's nature, type of contract and influences outside the MT's control. They can best be described under the following headings.

5.2.1 Additional works due to unforeseen technical problems

Two such examples described in paras. 5.1.2 and 5.1.5, illustrate the causes of the problems and their consequences.

5.2.2 Tight time schedule

Previous project's built by the MC for the Client were completed in an average time of ten months. Because of the tighter programme for this project, the float of the non critical activities was reduced. Thus:

- there was less time for decisions to be made and design information to be produced when problems of para. 5.2.1 occurred
- there was a greater chance that slip ups in the coordination of the flow of information among the DT, Client, MC and sub-contractors was likely to occur. eg delays in issuing AI's (to vary works or provide additional information) as in para 5.1.7 or late orders by the MC to the sub-contractors as in para 5.1.8a.
- disputes between the Architect and sub-contractors arose because some packages were tendered on vague information as in para 5.1.3.

5.2.3 Client's involvement

The Client could interfere with the progress of the works or cause cost increases by:

- requesting design changes as those explained in para 5.1.1a.
- delaying information, or to place orders to the DT or to suppliers for items directly in his control
- delaying decisions or information for items, such as the illuminated

signs, for which the Client's approval was required para 5.1.1b and c.

5.2.4 Management of sub-contractors by the MC

Some delays were caused by the sub-contractors due to:

- remedial works instructed by the Architect, Structural Engineer or M and E para 5.1.6
- late start on site by some sub-contractors (probably because of other engagements)
- drop in productivity, either because of inadequate supervision from the sub-contractor's Agent or because the sub-contractor did not provide adequate site resources.

5.2.5 Interference between sub-contractors

In some cases the sub-contractors' progress was interrupted as a result of:

- delays which occurred in preceeding packages as those of para 5.1.8c
- the way work had been allocated among packages as in the case of para 5.1.2.2
- site congestion ie sub-contractors working in the same area and interfering with each others work due to limited space para 5.1.3

Such delays usually resulted in claims by the affected sub-contractors for financial compensation. Such claims had to be substantiated with detailed accounts of the financial loss to the sub-contractor for the period his plant or labour stood idle.

In practice the substantiation of such claims proved difficult however as the affected sub-contractors were, where possible, diverted by the MC's Agent to other areas. (Thus although the sub-contractor's programme had been interrupted the financial loss was difficult to quantify).

5.2.6 Inclement weather

For delays due to inclement weather the affected sub-contractor was entitled to a time extension of his contractual programme.

Such delays were accepted by the MC if the sub-contractor had stopped working due to worse weather conditions than the average of those recorded in the meteorological records of the past ten years.

6. Effectiveness of the Contract Control System

6.1 Supervision costs

The total cost of the design and supervision was estimated at approximately £0.270m (fees of the DT and MC) ie 16.5% of the estimated final cost.

6.2 Benefits from the control system

The success of the contract's control system can be evaluated by examining whether it helped the project's MO to achieve the Client's expectations, which were outlined in para 2.4.

In the following paragraphs the fulfilment of those expectations is examined and the management performance (planning, monitoring and control of cost and time) under a management contract is compared to the management performance of a conventional contract.

6.2.1 Fulfilment of Client's expectations

- a. Time. All the members of the MT agreed that designing and building the project in twelve months (from June of Year 1 to June of Year 2 when the building was handed over) was a difficult achievement, especially as:
 - the design stage commenced without a defined design brief (in June of Year 1 when the MT met for the first time the Architect presented a first sketch of the building with the comment that it was provisional and likely to change considerably as the design progressed)
 - a number of design changes were introduced during construction
 - technical difficulties were encountered with the site's drainage

In the MT's opinion the Management Contract in comparison to a conventional contract shortened the project's design and construction span because:

- The two phases were partially overlapped, thus saving at least four months. (In the MT's opinion if a conventional contract had been awarded, the contractor could not have commenced work before the end of Year 1)
- The construction phase was shorter because of the MC's presence (whose contract is time biased), and the pressure he applied on the DT and to a lesser extent on the Client to make a design decision or produce design information as quickly as possible.

b. Quality.

- i) The Management Contract allowed, within limits, because of the partial overlapping of the design and construction, to alter or decide on several design aspects, architectural features etc, while the building was being erected instead of having to make such decisions from the drawings. This is an important advantage for Clients, who have no architectural background; and most of the private Clients do not have this background.

It was important however that the Client was made aware by the PM (para 4.3.1.1b) that after the construction had progressed beyond a certain stage, certain changes because of their cost and time implications were not cost effective.

Two such examples were the following:

- When the canopy was erected, the MD during one of his visits to the site, suggested that the canopy looked considerably smaller than in the layout drawings and wondered whether it would offer adequate protection to the loading bay area.

The PM on the DT's advice explained that it was as designed and that the extra cost increase

and time disruption involved if the canopy was to be enlarged at that stage would have been considerable. Thus the matter was not pursued any further.

- Changes in the bakery area, requested by the PMR in March, in order to improve the functioning of the area were also not implemented because of the disruption they were likely to cause to the sub-contractors..

ii) During the course of the construction, a number of complaints were expressed by the PM and DT about:

- the quality of finishes ie concrete blockwork etc
- the extent of remedial works that had to be ordered
- the response of sub-contractors to instructions from the DT, communicated to them through the MC, concerning methods of construction or remedial works eg the Structural Engineer in consecutive policy meetings expressed his dissatisfaction with the concrete finish of the car ramp.

Similar complaints had been expressed by the PM about previous projects built on a cost plus fee basis, or by a management contract.

The above problems could be attributed to:

- the high priority placed by the Client on finishing the projects in progressively shorter periods
- the fact that the MC's Agent had to control labourers chosen and employed by the sub-contractors.

c. Cost. There seemed to be a variety of opinions among the MT members as to whether using a management contract is a more expensive way of building a project than under a conventional contract.

Some of the for or against arguments outlined below are straight-

forward while others are difficult to quantify or prove.

- i) The design and supervision cost (para 6.1) of the management contract was considerably higher than the fee that would have been paid to the professional disciplines under a conventional contract, mainly because of the MC's fee.

This additional cost was partly balanced, in the PM's opinion, by the financial gain of the Client because he directly sub-contracted all the works of the project.

(The PM had estimated from previous projects built under conventional contracts that every part of the works the main contractor sub-contracted directly was agreed at approximately 2.5% less than the contractor had quoted in his tender offer to the Client).

- ii) It is probable that for future projects the Client will have to pay a higher fee to members of the DT, especially when there is a high demand for consultants, in order to compensate for the higher supervision costs they have to undertake under a management contract (more paperwork, meetings etc).

The following example illustrates the reasons for the above prediction. In November the DT and MC realised that the M and E was not cooperating in the project's management (late information, absent from policy meetings etc). The matter was raised in a policy meeting.

The PM pointed out that the M and E had explained to him that:

- his fee, because of the small amount of M and E works, was too low to cover the high supervision costs. Under this fee he could only complete the design drawings and specifications and once the job was completed he would inspect the M and E works and issue the completion certificate. He also pointed out that this arrangement should be satisfactory as the MC was paid to carry out the project's

management

- if he was to participate in the management during the construction his fee would have to be reviewed and raised by 20%.

The MC's RD agreed that under ideal conditions the DT should design the project, the MC should manage the resources, and once the job is finished, the final product should be inspected by the DT.

He pointed out however that this is far from realistic because in real life a lot of information is required by the MC from the DT and it was vital that this information should be supplied quickly if delays and claims are to be avoided.

A compromise was later worked out among the MT members in order to alleviate the M and E's management burden; it is obvious however that the problem is there and could occur again.

- iii) Some members of the DT agreed that because of the depressed construction demand in the building industry at the time the project was built, the Client would have received really low tender offers from conventional contractors.
- iv) It is difficult to evaluate the net cost increases or cost savings due to the high construction schedule. The PM did not believe that under a management contract the project costs are increased because the Client is encouraged to initiate more changes than under a conventional contract.

d. Planning, monitoring and control of time and costs.

- i) Time. The bar chart was not revised although from November because of the site drainage, the duration and nature of the activities had changed and it became known that the contractual completion date was going to be overrun.

Thus in the CM's report, delays were reported against the original programme.

Soon, all the activities were reported as being late, especially as the MC in his reconciliation sheet front-loaded the float of all the non critical activities.

By front-loading the non critical activities and not updating the programme the CM believed that reporting was less confusing to the policy meeting participants; but more important the DT members were urged to produce the design information as quickly as possible so that delays due to late information were not reported.

It should be noted however that because of the programme's front loading the DT's workload was unevenly distributed and their resources were therefore strained at times; a problem which was further exaggerated when additional works were requested. Some anxiety and in some cases, tension, seemed to develop when such delays and their reasons were reported by the CM at the policy meetings.

The meetings fulfilled their role very well, because all the disciplines of the MT were involved with the management of time, cost and quality, irrespective of their professional objectives. They also served as a reminder for each member as to the obligations each one had to the remaining members of the team.

When sub-contractors fell behind their programme the MC pressured them (par 3.3.2) to increase their labour force or to work overtime without additional compensation from the Client.

A number of such actions were reported by the MC during the policy meetings.

It should be remembered however that the effectiveness of the MC's control of the site resources was also influenced by the following uncertainties:

- The sub-contractor's labour force and site management was chosen by the sub-contractor. It was therefore possible that a sub-contractor could have proved reliable in previous jobs carried out for the MC because he used a responsive labour force. There was no guarantee however that the same individuals were going to be used on this job.
- The MC's Agent had to control labourers employed by the sub-contractor.

ii) Costs. It may be argued that the EPC's total cost estimate was less accurate than a prediction based on a conventional contracts of tendered prices would have been (provided that the priced bill did not contain a high proportion of PC and provisional sums) because of the cost estimates of the unlet packages it contained.

This argument may be illustrated by the gross underestimation of the expected discounts (by £0.110m) mentioned in para 1.4.

Such overestimations (or underestimations) are likely to occur because the market conditions at the time a package is tendered can not be predicted when the EPC is produced. For example, when the package for painting and decorating was tendered in March, the offers received were substantially higher than the cost estimate in the EPC because the LA had tendered a lot of similar contracts.

The settlement of claims was slow, as it is under conventional contracts and thus predicting the project's final cost was rather difficult (see para 1.4).

Monitoring of committed costs was tight because of the pink slips

issued by the MC.

The cost estimating of the let packages was therefore more accurate than under a conventional contract, where the AI's are not recorded as promptly.

In order to control costs the QS and MC's QS evaluated alternative solutions to technical problems and requests for design changes by the Client before an AI was issued.

The remaining AI's were evaluated after they had been issued (pink slips).

The implications of the above observations on the budgeting, forecasting, monitoring and control of costs can be summarised as follows:

- The Client's decisions to proceed with the project and reserve the budget were taken long before the EPC had been produced. Thus the EPC's degree of accuracy did not affect the above crucial decisions; indeed the Client reserved the budgets of his projects on considerably less accurate information (see para 2.3).
- By the time the EPC was produced the Client had committed approximately 50% of the project's total expenditure in terms of fees, contracts etc which made it difficult for him to abandon the project if the EPC's cost estimate was too high.
- Overexpenditure or underexpenditure could not be predicted until the last few months of the construction phase because of the EPC's inaccuracies and the slow settlement of claims.
- Control of costs was exercised by tightly monitoring committed expenditure and evaluation of certain categories of design changes, before an AI to vary the works was issued. Both the QS's agreed that if they had been issued, irrespective of their purpose or implications, the project's progress would have been delayed.

7. Comments, Conclusions and Improvements

7.1 Type of contract

Based on section 6 it can be said that because of the choice of the management contract:

- the project was built more quickly, but most probably at a higher cost than under a conventional contract
- the Client authorised the commencement of the construction with a provisional brief to the MT, and was in a position to request a number of design changes, although as the works progressed the cost implications of such changes were comparable to those under a conventional contract.

It can therefore be concluded that the Client should opt for such a contract if he is certain that:

- a. the revenue from the time saving, exceeds the increased capital cost.
- b. the project's concept, because of its purpose, is vulnerable to design changes because of outside pressures (eg commercial, technological innovations etc), which can be requested within certain time limits.

If the Client undertakes a number of similar projects every year, as it was the case of this Client, it is likely however that the number of changes he requests is likely to diminish as he becomes more experienced. (Members of the MT pointed out that the Client requested less changes than in previous projects).

7.2 Other types of contracts examined

The PM considered some other types of contracts under which projects

could be built as quickly but more cheaply:

- a. Cost plus fee. Prior to this project the MC had built some projects on a cost plus fee basis.

The Client switched to management contract on the QS's advice. The QS believed that by tendering all the works, especially in a period of recession, the Client was likely to receive low tender prices. Within the MC's personnel there was a difference of opinion. The MC's QS believed that a management contract was preferable because the MC undertakes less financial risks than under a cost plus fee.

The CM and Agents preferred cost plus fee contracts. The reason was that under such a contract the critical activities were carried out by the labourers directly employed by the MC and thus the Agent could manage the works better.

- b. Design and construct. The MC and a number of other contractors specialising in design and construction had suggested to the PM that such a contract would be less expensive for the Client (for example the fee of the DT would be reduced from 10% to 5%) while the project would be completed as quickly as under a management contract.

Such a contract was not practical however because of the way the Client chose his sites, none of the contractors was willing to become involved with investigations of numerous sites - the majority of which were rejected.

7.3 Project's management organisation

All the members of the MT agreed that if the tight progress targets of a management contract are to be achieved, as it was demonstrated in

this project, they have to be in close cooperation among themselves and with the Client.

It is therefore important that:

- a. The Client needs to appoint a member of his staff who would be closely involved with the project's management.

By appointing the PM the Client obtained the following benefits:

- a member of his staff was fully informed of the project's progress and committed costs. The PM could therefore advise the Client on the implications of changes requested by various departments before they were initiated by the PMR
- the PM, because he was a member of the Client's organisation and was based in the HQ, could pursue decisions and obtain them quickly, for which the Client's consent was required
- a continuity of choices of materials, in order to reduce maintenance cost, was maintained.

It is important to note however that the PM did not make design decisions. Thus:

- design decisions, concerning choice of structural elements etc were made by the DT
- design decisions and design changes concerning the building's functioning were taken by the MD and Retail Director and drawn up by the PMR. The PMR made recommendations to the MD but did not act without their authority on major design changes.

- b. The Architect, QS and MC, each one of whom is responsible for the control of quality, cost and time respectively, should be coordinated if the Client's expectations are to be fulfilled.

The role of meetings (design, policy) is very important in the

coordination of the three disciplines.

- c. The responsibilities and duties of all the members of the MT should be clarified from the first meeting, especially when the DT disciplines have not worked with the MC before. (For example the project's Client had a long standing agreement with the MC but in most cases new DT's were employed for every new project, see para 3.2)

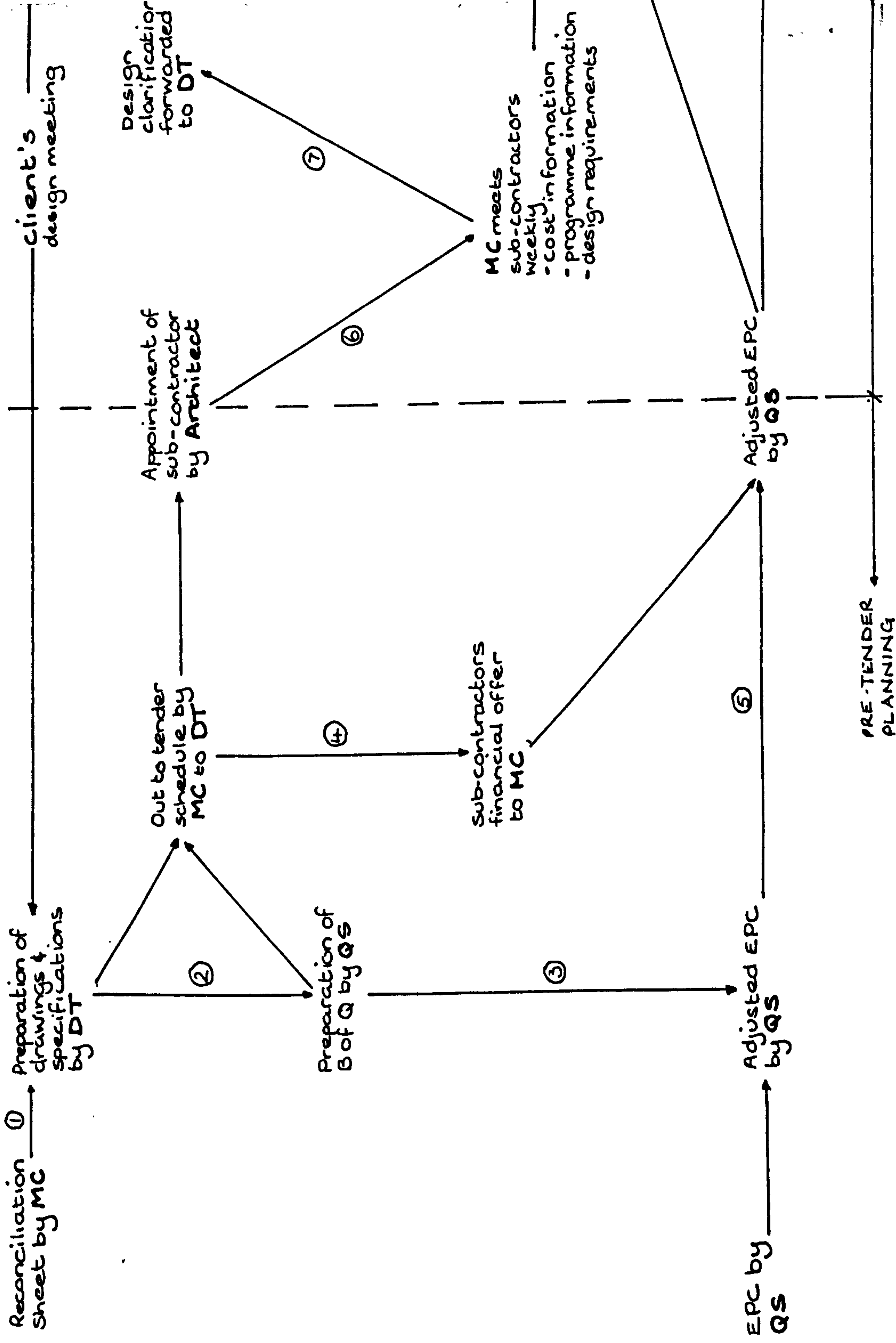
Thus future tension or misunderstandings within the MT can be avoided because:

- the DT members know from the beginning of the work load they are likely to undertake and thus complaints such as in the case of the M & E can be avoided
- the MC's input into the MT may be widened since the apprehension of the DT members towards the MC's role in the MT mainly based on the Architect conventional contractor relationships they have always worked under, can be dissolved, for example in this project there was very little feed in the design decisions from the MC
- misunderstandings about the exact responsibilities of the DT's members will be clarified eg the Architect knows when he has to issue instructions.

PROJECT'S CONSTRUCTION PHASE

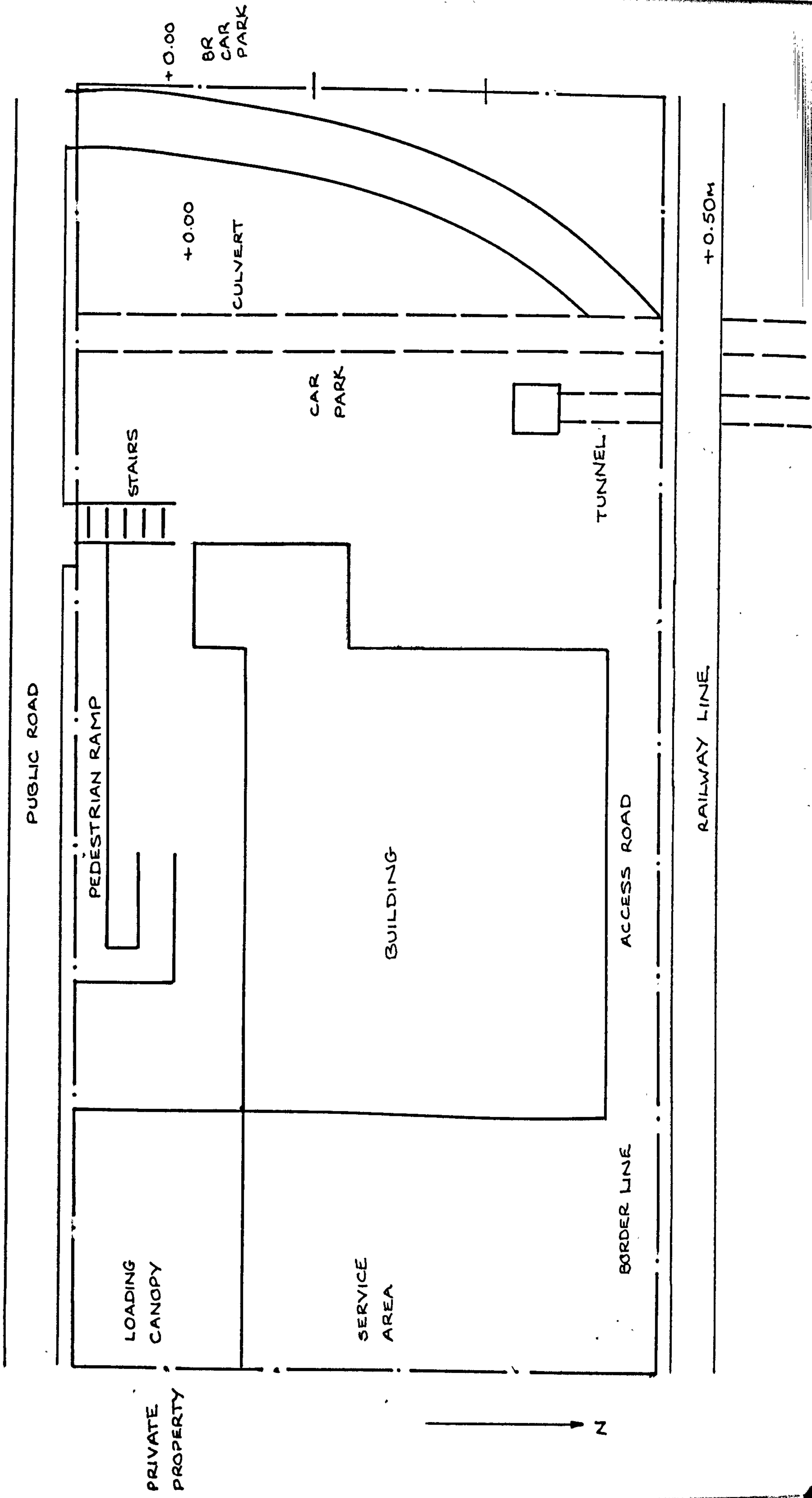
TENDER STAGE OF A PACKAGE

PACKAGE'S CONSTRUCTION



APPENDIX I

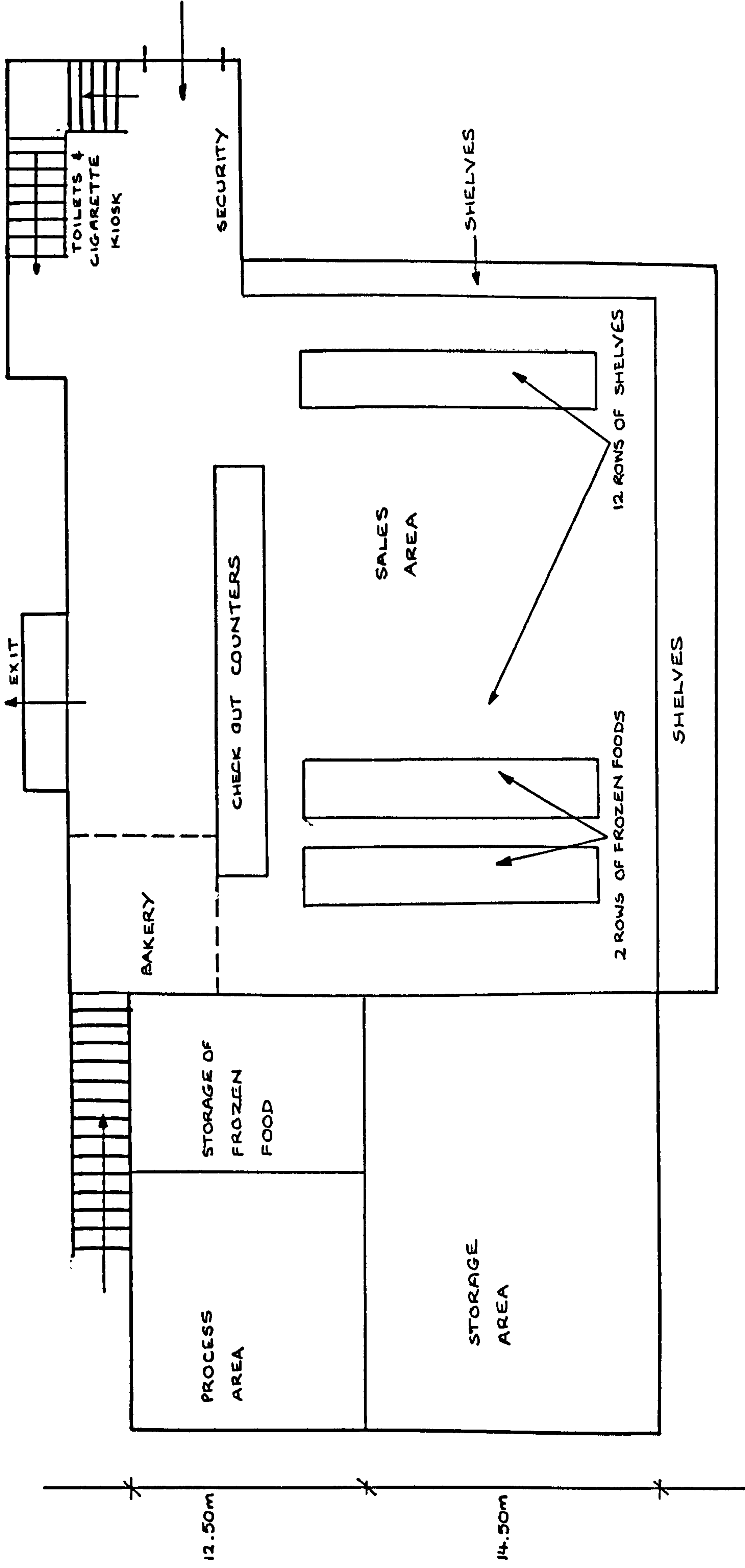
LAYOUT OF SITE (SKETCH NOT TO SCALE)



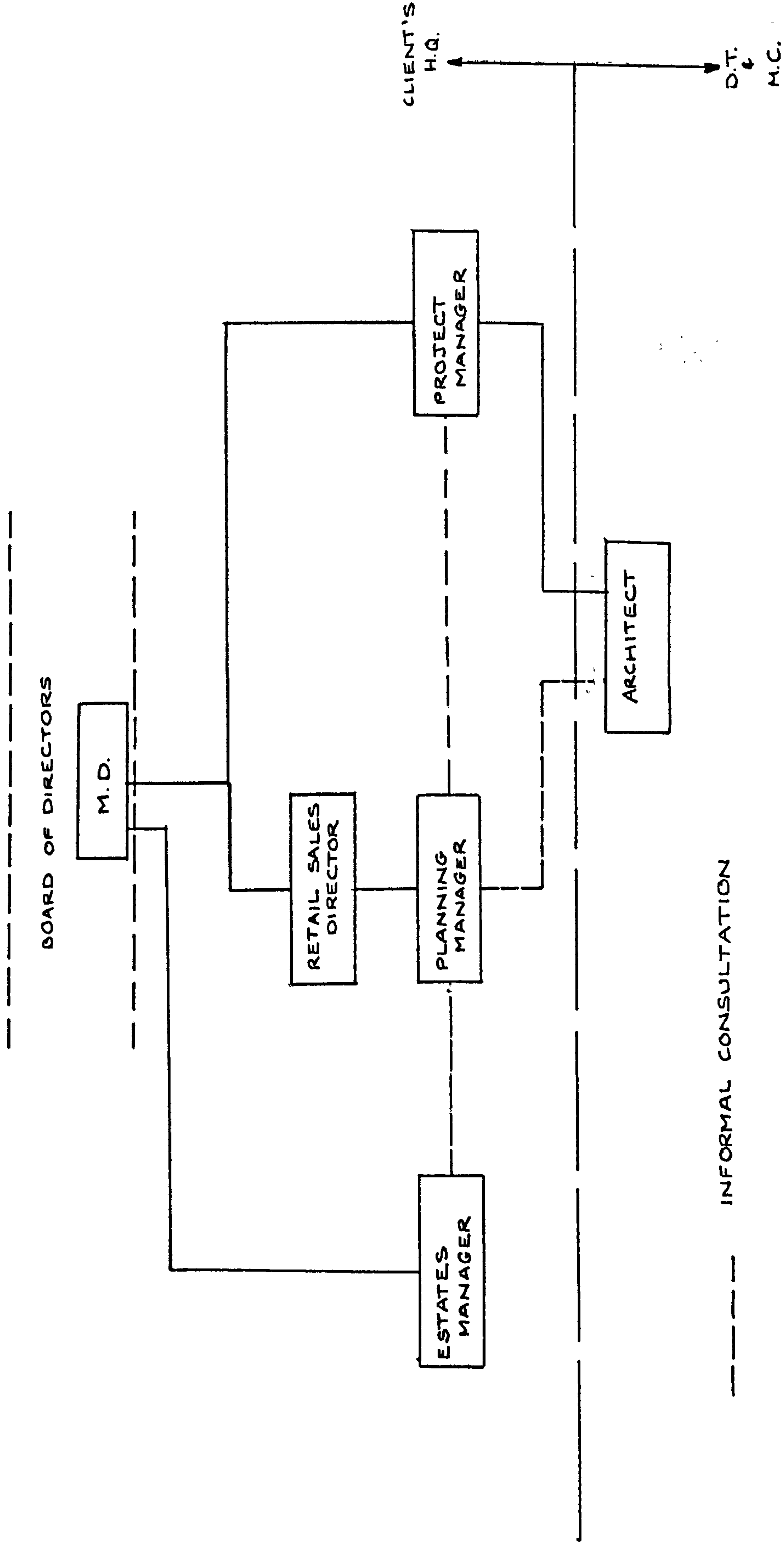
LAYOUT OF BUILDING'S GROUND FLOOR

(SKETCH NOT TO SCALE)

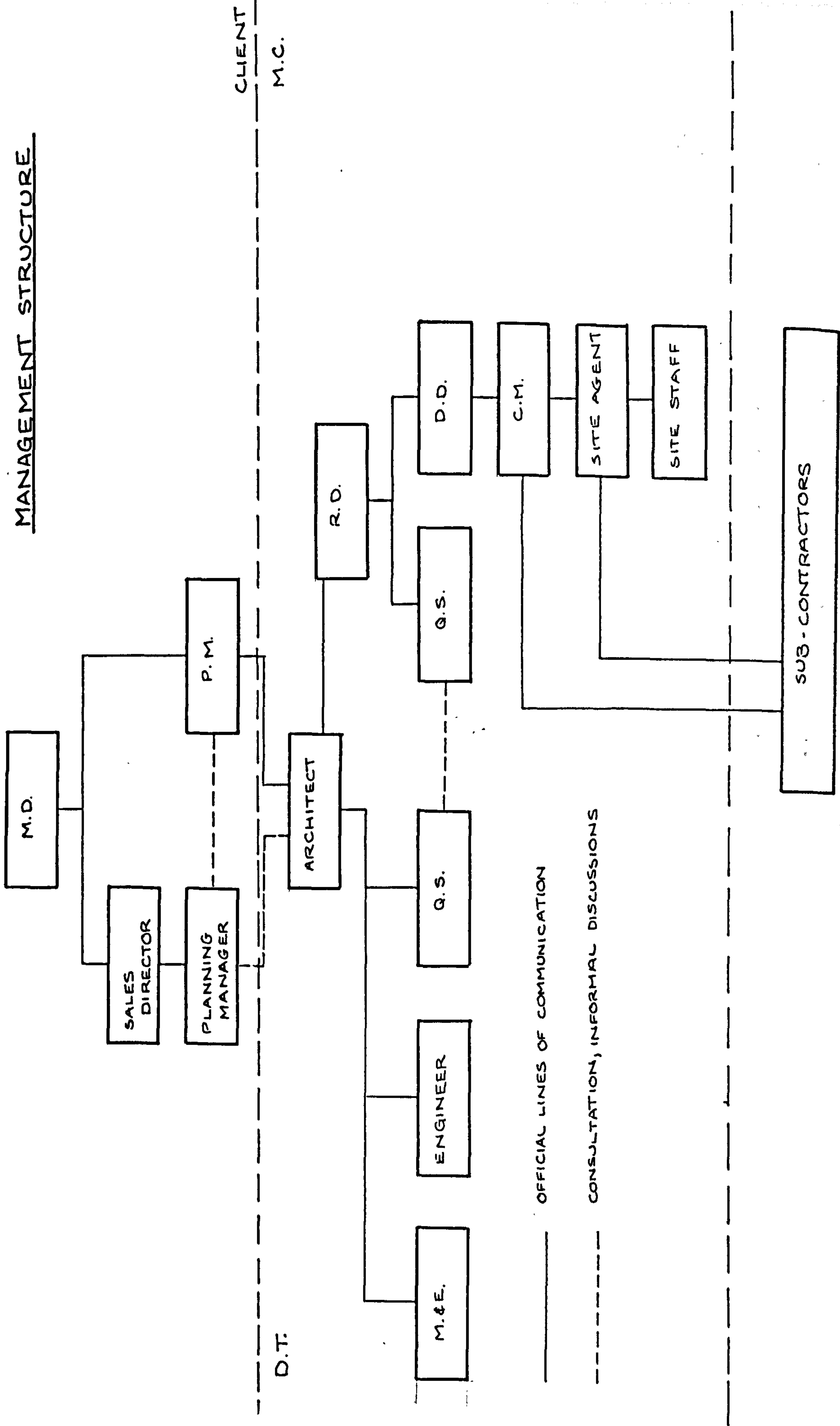
13.0m



CLIENT'S STRUCTURE



MANAGEMENT STRUCTURE



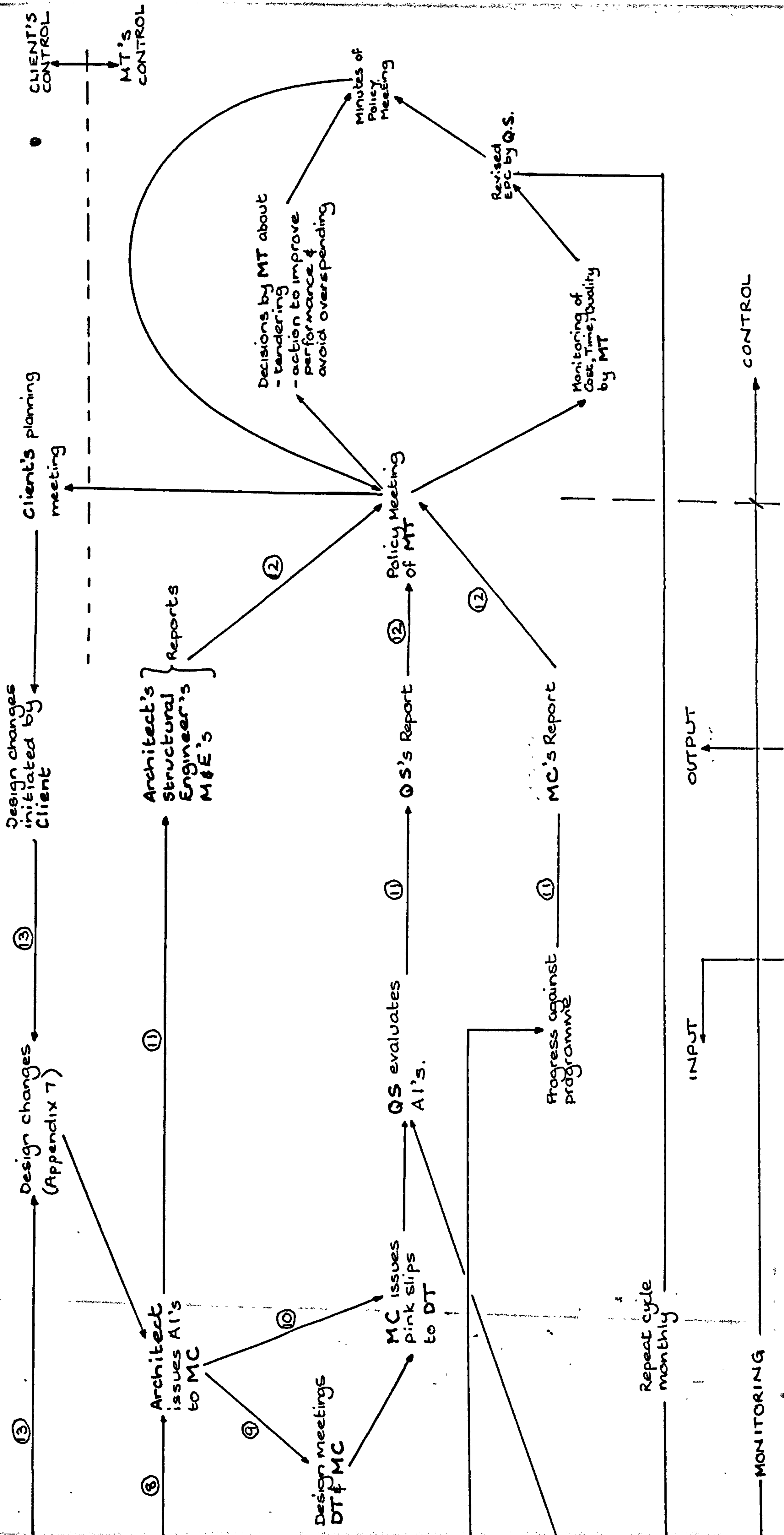
DUTIES OF M.T.

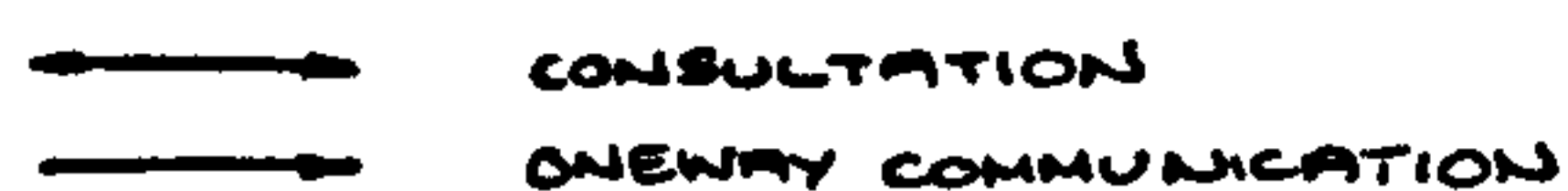
TEAM	MEETING BRIEF	DESIGN DEVELOPMENT MEETING	MEETING TO APPROVE PROGRAMME & EPC FREEZE BRIEF	SIGN MANAGEMENT CONTRACT	POLICY MEETINGS	POLICY MEETINGS	POLICY MEETINGS	POLICY MEETINGS	POLICY MEETINGS OF BUILDING
CLIENT									
ARCHITECT/ ENGINEERS		PRODUCE SKETCH DESIGN PRODUCE SCHEME DESIGN		PRODUCE DETAIL DESIGN	PRODUCE WORKING DRAWINGS				
Q.S.		PRODUCE EPC		CONTINUOUS PROGRAMME OF BILLING & TENDER DOCUMENTATION. MONITORING EPC & AGREE WITH SUB-CONTRACTORS FINAL ACCOUNTS			PREPARE FINAL ACCOUNTS		
M.C.		DETERMINE WITH CONSULTANTS OPTIMUM DESIGN SOLUTIONS. AGREE & FINALIZE EPC. EARLY DISCUSSION WITH SUB-CONTRACTORS. SELECTION & APPOINTMENT OF FIRST SUB-CONTRACTORS		CONTINUOUS PROGRAMME OF TENDERING & SELECTION OF SUB-CONTRACTORS ASSIST QS TO MONITOR EPC & PROGRESSIVELY AGREE THE FINAL ACCOUNTS OF SUB-CONTRACTORS				PRESENT FINAL ACCOUNTS	
SUB- CONTRACTORS				COMMENCE CONSTRUCTION	CONSTRUCTION		COMPLETE CONSTRUCTION		

TIME AND 'COST CONTROL

APPENDIX 6

PHASE





TYPES OF CHANGES

5. INITIATED BY PMR OR MD
7. REQUESTED BY DT
8. REQUESTED BY PM
9. REQUESTED BY MC (TO IMPROVE PERFORMANCE OR TO OVERCOME TECHNICAL PROBLEMS)

CONTENTS OF MC's REPORT

Page 1 contained a table showing the planned, achieved and forecasted according to plan progress of the let packages as a percentage of the total amount of the work for that package.

The commencement and completion dates of the project also appeared in the same table.

The programme percentages were derived by assuming that the total work of the package was evenly distributed over its total time duration.

Page 2 was a supplement of page 1 and contained comments on the progress of each package. It also contained a summary of the effects of the delays on critical packages on the overall programme.

The purpose of pages 1 and 2, according to the CM, was to inform the participants of the so far progress of the works.

Page 3 A table showing the average daily labour force provided by the sub-contractor and the MC on site during the past month.

According to the CM it was a rule of the MC to present this table.

Page 4 A table showing who has to provide information, or in the case of the Architect, instructions (AI), and the date by which the MC requires them.

The CM saw this table as a coordination tool between the MC and DT.

It was also a safeguard for the MC since he could prove that the requirements were made in time.

Note The table contained outstanding information or AI required during the past months. It also contained information and AI required for the next month. Once the information was received it did not appear in the next report.

Pages 5-8 Lists of drawings required by the DT.

Date by which they were required and dates by which they were received.

The lists were prepared and issued to the members of the DT before any packages were awarded.

The dates by which they were required were related to the bar chart.

Page 9 A review of the appointed sub-contractors.

This table contained the names of the sub-contractor, the dates of commencement and completion, and brief comments. The comments were related to the progress of the works or actions to be taken so that the works commenced or were carried out according to the programme.

The purpose of the table was to be used as a quick reference. As the works progress the actual dates of start and finish will appear as opposed to the programme dates.

Page 10 Monitoring of the sub-contractors and suppliers reconciliation sheet.

The CM commented that there was duplication between the contents of pages 9 and 10.

As the works progressed, page 9 was extended and its importance was increased while the importance of page 10 was diminished, especially when all the packages had been sub-contracted.

Two more tables appeared at the end of the report as appendices.

1. Schedule of elements of all the M and E packages. (Drawn out of tables of page 10).

2. The AIs the MC received during the past month. (Since the last policy meeting).